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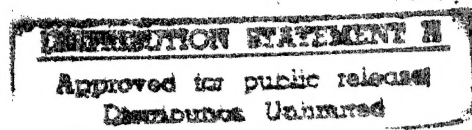


Quick Response Analysis Requirements and Methodologies (QRAM) Mini-Symposium

General Chair: Dr. Jacqueline Henningsen
Office of the Director
Program Analysis & Evaluation, OSD

30 September - 3 October 1996
McLean, Virginia

Date of Report: 13 December 1996



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Quick Response Analysis Requirements and Methodologies (QRAM) Mini-Symposium

**General Chair: Dr. Jacqueline Henningsen
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The Military Operations Research Society (MORS)

The purpose of the Military Operations Research Society is to enhance the quality and effectiveness of classified and unclassified military operations research. To accomplish this purpose, the Society provides media for professional exchange and peer criticism among students, theoreticians, practitioners, and users of military operations research. These media consist primarily of the traditional annual MORS symposia (classified), their published proceedings and abstracts, special mini-symposia, workshops, colloquia special purpose monographs and other publications. The forum provided by these media is directed to display the state of the art, to encourage consistent professional quality, to stimulate communication and interaction between practitioners and users, and to foster the interest and development of students of operations research. In performing its function, the Military Operations Research Society does not make or advocate official policy nor does it attempt to influence the formulation of policy. Matters discussed or statements made during the course of its symposia or printed in its publications represent the positions of the individual participants and authors and not of the Society.

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- The Director of Force Structure, Resource and Assessment, The Joint Staff
- The Director Program Analysis and Evaluation, Office Secretary of Defense

MORS Mini-Symposium

Quick Response Analysis Requirements and Methodologies (GRAM)

General Chair Dr. Jacqueline Henningsen,
Office of the Director
Program Analysis & Evaluation, OSD

Co-Chairs Mr. Robert Statz Dr. Roy Rice
Booz Allen Hamilton Teledyne Brown Engineering

Technical Chair Mr. Douglas Williams
Booz Allen Hamilton

Speakers Mr. William Lynn Director, OSD/PA&E
Mr. William O'Neil Vice President, CNA
Dr. James Ignizio University of Virginia
Major General Mark Hamilton Deputy Director, Joint Staff/J-8
Dr. Paul Davis RAND

Synthesis Group Dr. Paul Davis RAND
Dr. Stuart Starr MITRE
Mr. Clayton Thomas Air Force SAA
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Issue Category Leaders

C4ISR	Mr. John Osterholz	Deputy Director, CISA
	Mr. Mark Herman	Booz Allen Hamilton
Readiness	Mr. Joseph Angello	Dep Director, OUSD(Readiness)
	Mr. Robert Holz	Army Research Institute
MOOTW	RADM Gary Wheatley	Evidence Based Research
Infrastructure	Mr. Dan Barker	OD/PA&E/Resource Analysis
Force Structure	Mr. John (Bob) Statz, Jr.	Booz Allen Hamilton
Modernization	Dr. David Graham	Institute for Defense Analysis
WMD	Mr. Bruce Bennett	RAND
	Mr. Patrick McKenna	USSTRATCOM/J53

Preface

On October 1-3, 1996, a MORS mini-symposium called *First Order Analysis: Quick Response Analysis Methodologies (QRAM)* was held at the Booz Allen Hamilton Conference Center in Tyson's Corner, Virginia. The purpose of this special meeting was to focus on analytic processes and methodologies to gain first order understanding of Quadrennial Defense Review (QDR) related issue categories and to frame quick response issue requirements and methodologies. The Agenda for the mini-symposium is provided at Appendix E. A roadmap that summarized the proposed process for quick response analysis is shown in Figure 1. A writing workshop for issue category leaders to prepare the summaries found in Appendix C & D was held on the last afternoon of the mini-symposium.

This mini-symposium was organized in record time in response to the request of the Director, Program Analysis and Evaluation, Office of the Secretary of Defense with the concurrence of the other MORS sponsors. The long-standing efforts of the Joint Staff sponsor, Mr. Vince Roske, to develop a framework for quick-response analysis, provided the conceptual foundation upon which the mini-symposium was planned.

As always, this meeting would not have been possible without the outstanding support of the MORS staff of Dick Wiles (Executive Vice President), Natalie Addison (Vice President for Administration), Cynthia Kee LaFreniere (Assistant Administrator), and Michael Cronin (Editorial Assistant). In addition, MORS thanks Booz Allen Hamilton for the use of their outstanding Conference Center and the support of Administrative Assistant, Christine Donatone. Many other individuals, who are not specifically cited, generously contributed their time, insights, and leadership. These volunteers epitomize the MORS philosophy of providing quality support for the military operations research community.

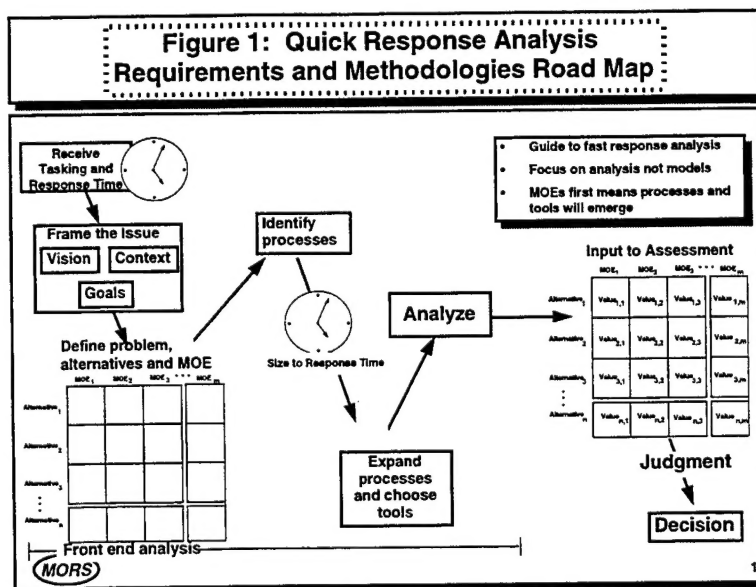


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Overview

1.0.0 Introduction

The Military Operations Research Society (MORS) held a combined mini-symposium and workshop on October 1-3, 1996 to focus on analytic processes and methodologies to frame quick response analysis requirements (QRA) and methodologies. At sponsor request, a primary focus of the meeting was to gain first order understanding of Quadrennial Defense Review (QDR) related issue categories. A copy of the QDR Congressional language is provided in Appendix A1. The objectives of this special meeting were:

- To use the skills of outstanding analysts across DoD to explore senior leaders' requirements for quick response analysis of major issue categories.
- To develop a taxonomy and categorize methodologies available to apply to these and similar issues.
- To use an organized analytic approach to frame these issue categories and to provide demonstrations of the application of this approach using existing case studies.
- To apply the organized analytic approach to specific issue questions within the issue categories, to identify applicable QRA methodologies, or to identify shortcomings in current response capabilities.

- To hold guided discussions on the uses and misuses of QRA methodologies.
- To provide a report of the results of the mini-symposium. *[An issue category matrix replaced a proposed preliminary catalog of methodologies].*

In preparation for the mini-symposium, a planning meeting was held on July 22, 1996. This planning meeting was attended by representatives of each sponsor, MORS executive council members, and others chosen for their experience with MORS meeting planning. Prior to the planning meeting, the organizing committee had solicited input on questions and debates likely to be raised as part of the QDR from a number of sponsors and other key department decision makers.

At the planning meeting, the organizing committee presented a condensed version of the planned mini-symposium, sought suggestions from participants and presenters, brain-stormed the issue categories using questions solicited from decision makers, described the objectives of the meeting, and provided a proposed report format. This meeting was pivotal in organizing the structure for the mini-symposium. Following the planning meeting, sponsors and members of the MORS board were asked to submit further suggestions and the names of nominees for the mini-symposium.

The QRAM mini-symposium was organized with three general sessions designed to establish a framework for quick response analysis and to identify the challenges of the QDR. These general sessions were followed by issue category working groups on specific issue areas anticipated to be part of the QDR. A road map showing a quick response analysis process that formed the framework for QRAM discussion is provided in Figure 1. An organizing matrix for issue category report preparation is shown in Figure 2.

According to feedback from the participants, the objectives of the meeting (with one modification) were accomplished. An overall taxonomy for categorizing quick response methodologies was extensively discussed during the meeting, and an organized analytic approach used to frame seven major DoD issue categories. Participants met to apply the organized approach to specific issue questions and to identify shortcomings. Guided discussions were held on the uses and misuses of QRA methodologies within each area. (Our sponsors had emphasized that they did not want this meeting to focus on models and model demonstrations, so the emphasis was on analytic process.) The common matrix of methodologies developed by each issue category working group replaced the development of a preliminary catalog of methodologies. (Section 2.0 contains the discussion of these issue category reports.)

The next sections provide general details of the meeting.

1.1.0 General Session

Presentations (See Appendix A2 for biographies.)

1.1.1 MORS President's Welcome.

MORS President Fred Hartman provided the following opening comments and introduced the keynote speaker, Mr. Bill Lynn, Director, Program Analysis & Evaluation, OSD.

This year the Military Operations Research Society (MORS) is officially thirty years old. As a way of counting, we are celebrating our thirtieth anniversary of incorporation under the laws of Virginia. However, the organization goes back some ten additional years to 1956 when scientists at the Office of Naval Research, Pasadena, started planning for the first Military Operations Research Symposium to be held at the Corona Naval Ordinance Lab in August 1957. The work of the Society has depended over the years on the volunteer work of its members and that is no exception in this important meeting.

In the roughly forty years of existence as a professional organization, we have seen significant development and rapid advances in the tools of our profession. The advent of the mainframe computer and later the increases in speed and micro-technologies have provided exciting challenging vehicles and techniques to enable analysis. The primary goal of MORS over the years has

Figure 1: Quick Response Analysis Requirements and Methodologies Road Map

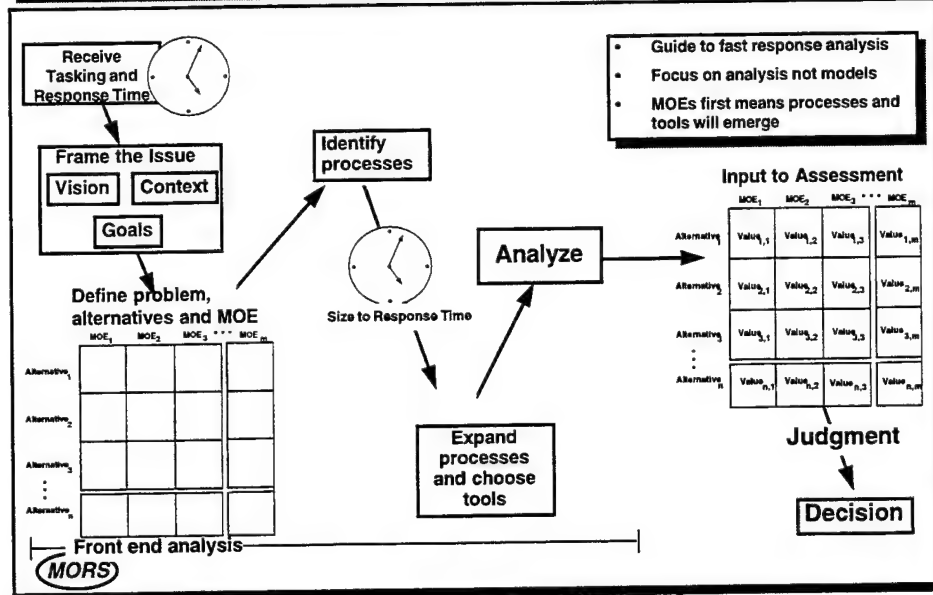


Figure 2: Issue Category Report Process

- Review where this issue category fits on the cube
- Identify several critical issue questions and list them
- Choose an issue question and frame it
- What are the analytic challenges
- Discuss possible MOEs
- Identify prior studies and their possible value
- Focus on a specific response time
- Propose methodologies
- Discuss possible uses and misuses
- Consider data issues
- Describe unresolved problems/presentation issues

	2 Days	2 Weeks	2 Months
If Base Is			
Warm			
Cold			

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remained constant, to enhance the quality and usefulness of classified and unclassified military operations research.

This combined Mini-Symposium/Workshop on Quick Response Analysis Requirements and Methodologies (QRAM) goes back to our very roots in MORS. The purpose of this meeting was to focus on analytic processes and methodologies -- not specific models or tools -- for application in the current process of the QDR. Attendees included senior analysts, managers, and academicians in the current operational defense environment -- in classic operations research form.

We are grateful for the great deal of work that has gone into the conduct and documentation of this MORS Special Meeting. Our sincere thanks is provided to our Sponsors, the Organizing Committee, the Issue Group Leaders, and in particular to General Chair Jackie Henningsen, Co-Chairs Bob Statz and Roy Rice, and Technical Chair Doug Williams. I would also like to thank Booz Allen Hamilton for making their beautiful facility available for this significant MORS meeting.

1.1.2 Keynote Address: What is the QDR? The keynote address was given by Mr. William Lynn, Director, Program Analysis & Evaluation, OSD. There is no text from his talk, but the following comments were provided as an overview of his main points.

Four years ago, the Clinton administration initiated a

department assessment known as the Bottom Up Review (BUR.) The limited preparation for this review was based on work by Secretary of Defense Les Aspin, when Chairman of the House Armed Services Committee, and Base Force II developed by Colin Powell. The debate surrounding BUR criticisms that (1) the identified force structure was inadequate to accomplish the tasks the military faces, (2) that the two major regional conflict strategy was flawed, and (3) that the resources did not match the strategy and forces (particularly concern about our ability to return modernization to adequate levels) frequently hides the real benefits of the BUR. First, the BUR was effective in bringing stability to the plane of debate and also stability in terms of the budget. The Congress largely approved the budgets based on BUR findings which has been valuable for program planning. The BUR also helped to clarify future threats by identifying the importance of Lessor Regional Contingencies, presence missions, and focusing more attention on the importance of weapons of mass destruction. Finally, Secretary Perry's addendum to the BUR focused Department attention on readiness, and we made sacrifices to meet that commitment.

Congress, following the initiative of the Commission on Roles and Missions of the Armed Forces, has now tasked the

Department to prepare a Quadrennial Defense Review (QDR) at the beginning of each Presidential administration. The general guidance for this review is provided in the "The Military Force Structure Review Act of 1996" (Appendix A1).

A QDR makes sense as a way for each new administration to reassess and approve the defense direction. It catalyzes DoD's analysis process, and crystallizes our thinking. In general, a review of this nature is already done in an ad-hoc way -- establishing an official pattern through the QDR is the right way to go.

A few of the analytic challenges we face in the development of the first QDR are (1) uncertainty about the dominant military challenges now that the luxury of a stable threat is gone, (2) issues of how to draft more funding into recapitalization (modernization and force structure were studied separately in the BUR), (3) determining how to account accurately for operations and support costs in ways that allow us to deal with disproportionate reductions in infrastructure and to identify the benefits of privatization and of acquisition reform, and (4) improve our ability to assess capabilities within projected budget levels.

Mr. Lynn also commented on several of the twelve areas identified for review in the QDR Congressional

language. He closed with a question and answer session.

1.1.3 Analysis in the Spotlight -- A Brief Overview. Mr. Will O'Neil, Vice President of the Center for Naval Analyses, provided a framework and set of "antinomies" for problem solving to include the differences in private versus public analysis. The text of his talk is provided in Appendix A3.

1.1.4 Intelligent Decision Systems Dr. James Ignizio presented a condensed overview of a five day workshop he gives on techniques for framing issues in terms of reasoning categories. He suggested that identifying issues as questions of induction, deduction, or other categories would help analysts determine the best assessment approaches. The slides from his talk are provided in Appendix A4.

1.1.5 Random Thoughts on Analysis. Major General Mark Hamilton, Deputy Director for Force Readiness and Resources, Joint Staff/J-8 used questions identified by decision makers prior to the planning meeting (Figures 3a and 3b) to discuss some of the analytic challenges of the QDR. There is no written report of his comments, but an example of the type of thoughts MG Hamilton encourages is captured in his response to the question "What is the value of investing in "tail" economies?" His comment was -- "what do you call a military airlift mission to deliver grain to a starving population?" "It's not tooth and it's not tail -- maybe", he suggested, "it's lips." He opined that

"we need more body parts." He challenged the participants to consider new viewpoints, including the implications of the "now-MRC."

1.1.6 Adaptiveness in National Defense. Dr. Paul Davis of RAND presented thoughts from his recent report of the same title in which he described the use of portfolio analysis to examine future force structure requirements. He cautioned that we must look at multiple scenario options including a review of the current two MRC policies with a rigorous investigation of uncertainties that have been previously considered lightly. This presentation by Dr. Davis was also extensively used by the Force Structure Issue Category Group. For Dr. Davis' report, see Appendix A5.

1.2.0 Framework Presentations

1.2.1 Framing the Issues -- The Methodology. Mr. John (Bob) Statz, Jr., QRAM co-chair, provided a road map that included the key elements for quick response analysis. See Appendix B1 for the presentation slides.

1.2.2 Methodology Demonstration -- What Is the Value of BDA? Mr. Doug Williams, QRAM Technical Chair presented an example of the issue framing and methodology development described in Bob Statz's "Framing the Issues" presentation. Mr. Williams' example shows how a difficult question on the value of bomb damage assessment (BDA) in the air tasking order cycle was assessed in a few days by

framing the problem in analytic terms using a simple visual model starting from a cold base. An interesting methodology that provides a way to explore trade-offs between weapon effectiveness, BDA effectiveness, and infrastructure investment was then developed in two weeks. Slides from this presentation are provided in Appendix B2.

1.2.3 The Art of MOE Development. Dr. Roy Rice, QRAM co-chair presented an insightful and somewhat humorous look at the role of the analyst in supporting the decision maker. He pointed out that decision making involves choosing among alternatives. It is a role of the analyst to (a) insure that there is an adequate range of alternatives, (b) establish meaningful criteria to distinguish among alternatives, and (c) insure trackability and traceability. His list of the types of MOEs to consider when looking at the twelve specific areas identified for the QDR in Congressional language (Appendix A1) is provided below. Dr. Rice's briefing is provided in Appendix B3.

Dr. Rice's slides Congressional Language Directs - - "*the report shall include...*"

(1) *...the force structure best suited to implement the strategy...*
{numbers of above the line forces, new organizations, roles and missions}

(2) *The threats examined ... and scenarios developed in the examination...* {numbers specific systems, force units, laydowns, doctrine/tactics/technology}

(3) *The assumptions ... cooperation of allies ... mission-sharing ... risk ... warning/duration ...* {probabilities, % of forces, flyover rights, % money, multiple sensitivities}

(4) *...effect on the force structure ... peace operations and [MOOTW] {OPTEMPO, robustness, training costs, etc...}*

(5) *...effect on the force structure ... technologies ... precision munitions, stealth, night vision, digitization, and communications ... changes in doctrine and operations concepts ...* {trade space (division vs. cruise missiles), logistics, strategic/tactical lift ...}

(6) *...manpower and sustainment policies ... support engagement ...more than 120 days...* {OPTEMPO, readiness, shore rotations, length of assignments, etc.}

(7) *...roles and missions of reserve components ... strength, capabilities ... equipment {AC/RC mix, unit organizations, acquisition plans, etc...}*

(8) *...appropriate ratio of combat forces to support forces ... Headquarters units ...* {personnel/personnel, dollars/dollars, units/units, organization changes}

(9) *...air lift and sea lift ... to support defense strategy ...* {closure times of WHAT forces and where, MTM/D, tonnage, risk ...}

(10) *...forward presence, pre-positioning ... for conflict deterrence and adequate response ...* {tons, units, MPS, days sustainment, Adequate response time, prob deter}

(11) *...extent to which resources shifted among two or more theaters...* {tons, units, time to

respond, swing forces, doctrine, tactics, air/sea lift}

(12) *...revisions to the Unified Command Plan...* {doctrine, tactics, deployment, warfighting capability/risk, command orgs ...}

2.0.0 Issue Category Reports

The questions shown in Figure 3a and 3b were identified by decision makers prior to the planning meeting. Using these questions as a starting point, brainstorming and framing activities were used during the planning meeting to identify nine issue categories. Two of these categories were eventually merged with others. These issue categories were divided into two, five hour sessions, and participants selected one issue category to attend during each session. The organizing committee identified experts with strong organizational skills to lead each issue category discussion. These leaders were provided with a process guide before the meeting, but were encouraged to use their own experience and judgment in deciding the best way to tackle their issue category.

A final planning meeting was held the evening before the meeting, and the leaders described the process they had chosen for their category. One of the key responsibilities stressed to the leaders was the requirement to prepare a draft of the final report during a writing workshop scheduled for the afternoon of the third day of the meeting. In the two weeks following the meeting (in all but one case) the draft reports were

Figure 3a: Quick Response Analysis Mini-Symposium
The Debates - The Programming Issues - The Analytic Challenges

Here are some of the questions they identified.

- What is the minimal force robust enough to maintain forward presence?
- How do we account for the uncertainty of the future world; the enemy, scenario, etc.?
- What are the trade-offs in modernization, force mix, and intelligence?
- What is the trade-offs in the I, S, and R? Between the C4I and ISR? etc
- What is the value of investing in "tail" economies: just-in-time, leaner system, interchangeable parts, automation?
- How can DoD reduce redundancies in long range strike assets?
- What is the optimal C3 investment; people, technology, communication?
- How will advancements in technology/communications impact operations and reduce infrastructure?
- What are the implications of increased use of unmanned systems in the battlefield?
- In a joint warfighting context are there redundancies across the services that can be exploited?
- Are there functions that can be performed by Reserve/Guard forces in place of Active forces?

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Figure 3b: Quick Response Analysis Mini-Symposium
The Debates - The Programming Issues - The Analytic Challenges

- What are the implications of precision weapons/smart targeting on munitions/lift requirements?
- What are the relative merits of overseas basing vs prepositioning equipment vs CONUS basing?
- What are the implications of non-traditional missions on our investment strategies?
- How do we determine the requirements for peacekeeping and humanitarian missions?
- What is the value of deterrence, how can it be measured?
- Some sponsors identified issues for the analyst
 - What are merits of requirements vs sufficiency analysis?
 - What are the benefits of investing in conditioning the data versus changing the models?
 - When are large scale models more appropriate and when are QRAM more appropriate? (Don't treat as just a time issue.)

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distributed to the issue category participants whose comments were solicited for immediate return. Participants' feedback was then used to modify the reports.

The common feature of each of the issue category reports was to be the matrix that contains the conclusions of the working group on how an issue could be analyzed with a two days, two week, or two month suspense considering a warm or cold starting base. The results of this effort ranged widely among working groups.

The C4ISR group chose to develop actual approaches to studying an issue given a two month suspense. This group met over two sessions, and were able to prepare three different recommended approaches to addressing an issue question. They observed that QRA is not the traditional process done faster, and that just framing the question required great energy and insight. They also pointed out that cost has a social dimension and takes more time as well as requiring scenario/system specific data which is the antithesis of parametric analysis.

The Weapons of Mass Destruction (WMD) group concluded that the need for a "warm" base of information is paramount and that the current analytic base is very segmented. Because of the complexities of Nuclear, Biological and Chemical weapons, an analyst starting from a "cold" base would be hard pressed to develop correct or useful analytic results.

The Military Operations Other Than War (MOOTW) group also was concerned with segmentation, as they noted that a warm base currently does not exist; it is necessary to integrate and normalize the various MOOTW data and databases so meaningful analysis can be performed. They reported that MOOTW has impacts on readiness and PERSTEMPO and multi-dimensional readiness indicators are required.

The Force Structure group observed that current approaches and tools are to a large extent tied to precisely-defined Major Regional Contingency threats and scenarios and system-driven force structures. They noted that dependence on these constructs to provide a warm base for QRA would preclude innovative approaches. They suggested the use of a RAND portfolio approach presented by Paul Davis of RAND to ensure that the analysis scope is as complete as possible and can lead, in time, to rational and explainable quantifiable and qualitative MOEs.

The Infrastructure group noted that most of the "low hanging fruit" has been gathered in this area and highlighted the problem of getting access to data from studies such as the Base Reallocation and Closure Committee work as a significant policy issue. In addition to the matrix, they also developed a list of illustrative infrastructure issues.

The Modernization group concluded that there is a good

chance that the community has analytical tools and data available in this area, although changes in strategy, mission, doctrine, threats, and technology may complicate their use. This group pointed out that we should consider process and institutional issues as well as the end product issues of force structure, modernization, readiness, and sustainability.

Since each group dealt with a very complex area, readers are encouraged to review the individual summary reports provided in the Appendices C1 through C7 and the report of the Synthesis Group..

3.0.0 QRAM Meeting Summary

3.1.0 Administrative Notes. One hundred seventeen participants were involved in QRAM. This is the second meeting in the last two years that was prepared as a quick response to a key decision maker or sponsor's request. Two years ago, the *Joint Requirements Oversight Council Workshop* was developed in just under five months to respond to a request from the Vice Chairman of the Joint Chiefs of Staff to engage the analytic community in the Joint Warfighting Capability Assessment process.

QRAM was developed in just over three months following approval to proceed by the MORS sponsors at the annual symposium in June. Mr. Bill Lynn, Director of Program Analysis and Evaluation had requested that MORS help the analytic community prepare for quick response analysis for an upcoming

department review. Mr. Vince Roske, the Joint Staff sponsor, had already been encouraging analysts to focus attention on quick response analysis requirements and methodologies. The linkage to the QDR was not identified until the Congressional Language was officially reported on July 30. Up to that point, the focus was on quick response for general questions like those identified by the key decision makers and shown in Figure 3a and 3b. The late identification of the relation to the QDR caused some problems for participants interested in learning more about a broad category of tools and methods. The skill and experience of the issue category leaders were pivotal in merging the strengths of all participants.

3.2.0 Synthesis Panel. A Synthesis Panel led by Dr. Paul Davis, Dr. Stuart Starr, and Mr. Clayton Thomas with support from Ms. Susan Iwanski, Dr. Richard Hayes, Mr. Richard Helmuth, CDR Dennis Baer, Ms. Christine Fossett, and Dr. Roy Rice met with the issue category leaders at the end of their sessions and prepared a report of cross-cutting ideas. The panel drew on the meeting objectives, insights from the plenary speakers, and inputs from the various issue groups and individuals to synthesize information from the meeting. They provided the attendees with preliminary ideas during the closing session and then refined their report based on participants' feedback. They constructed their observations and recommendations in two broad categories: those directly relevant to

the QDR and those with more long-term significance. Within each category they commented on the process, methods, and substance. They tried to keep in mind that there were two distinct target audiences: the analyst community and the consumers of analysis within the government. The Synthesis Panel report is provided as the Executive Summary.

short two and one half days and considering the complexity of the QDR issue space. It is hoped that they will continue to contribute to the development of quick response methodologies by submitting observations to QRAM co-chair, Dr. Roy Rice, through the MORS office.

3.3.0 Concluding Remarks

3.3.1 Analyst Feedback. Mr. Clayton Thomas prepared an additional report on specific observations for MORS analysts and as feedback for the preparation of future MORS special sessions. For Mr. Thomas's report see Appendix D2.

3.3.2 General Chair Observations. The issue category leaders and participants and the synthesis group did an outstanding job of considering quick response requirements and methodologies in light of the QDR. In addition many individuals, who are not specifically cited, generously contributed their time, insights, and leadership. Some observations by the general chair based on discussions with participants and members of the organizing committee are provided in Appendix D1.

A list of the participants in QRAM is provided as Appendix F. These participants came from organizations across the Department. It was difficult to capture the breadth of their knowledge and experiences in a

Report of Synthesis Panel
Dr. Paul Davis, RAND, Dr. Stuart Starr, MITRE

Report of Synthesis Panel

Paul Davis, Stuart Starr, Clayton Thomas

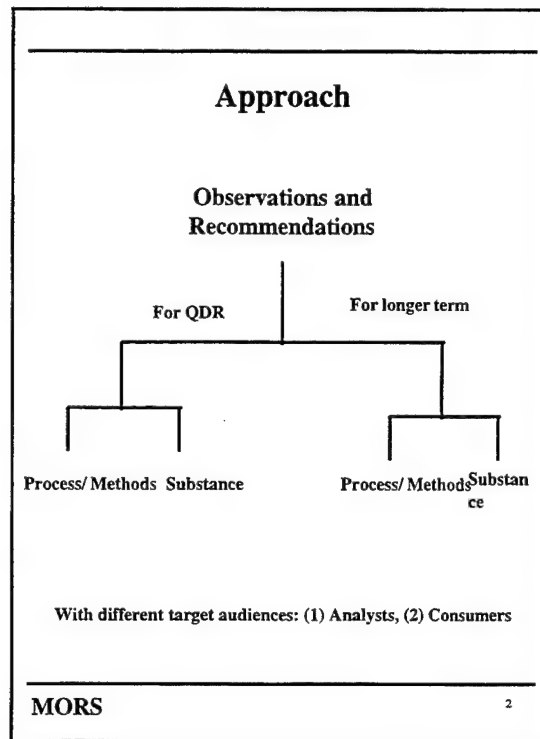
**MORS Mini-Symposium on Quick
Reaction Analyses and
Methodologies (QRAM)**

October 1-3, 1996

MORS

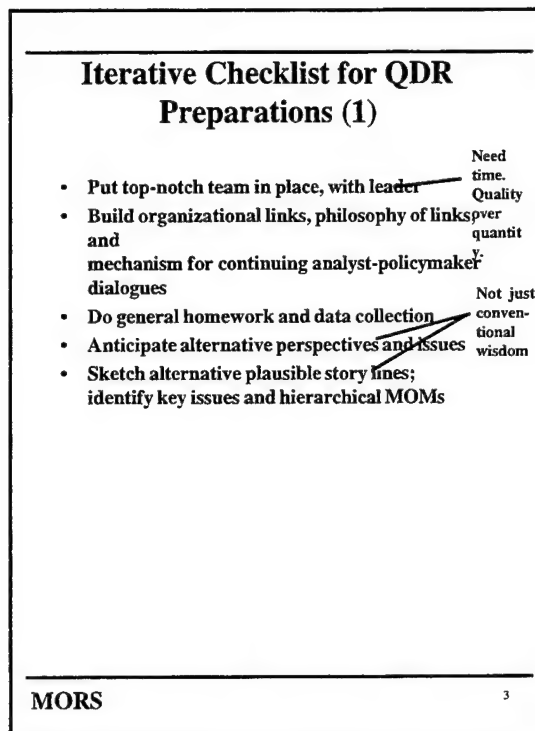
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This briefing summarizes the work of the Synthesis Panel. The Synthesis Panel consisted of the three principals identified in the vugraph, augmented with several symposium attendees who participated in the symposium breakout groups and periodically participated in the Synthesis Panel deliberations.



The panel began by drawing upon the terms of reference, insights of the various plenary speakers, and inputs from the various issue groups and individuals. We then added our own ideas, exposed them to the full group in plenary, received feedback, and iterated. We believe that we captured many ideas on which there was consensus, but we are ultimately responsible for the results and make no claims that everyone in attendance agrees with what we present here.

In contemplating how to proceed we concluded that we should construct useful observations and recommendations in two broad categories: those directly relevant to the Quadrennial Defense Review (QDR) and those with more long-term significance. Within each category we would comment on process/methods and substance. Finally, we would keep in mind that there were two distinct target audiences: the analyst community and the consumers of analysis within the government.



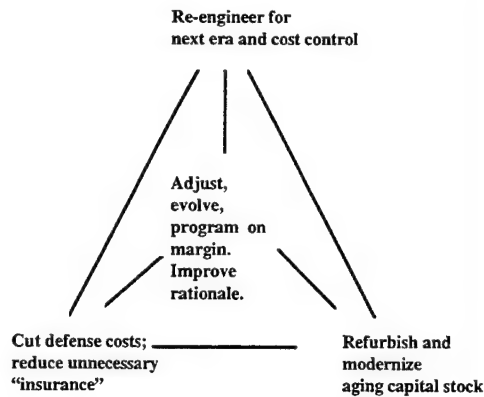
Let us first consider a number of slides, oriented toward those who will be directing QDR analyses, that provide a checklist of actions. An abstract version could be found in any of many texts and would already be fully understood. Here, then, we attempt to be more pointed about what is not really so straightforward. For example, the need to select a team and a leader is obvious, but less obvious is the value of doing so early enough for the team to learn to work together and do their homework, including some of the mind-stretching variety.

The second item seems to us especially important: not only must each QDR analytic group establish links with others, it must also decide (or be given guidance on) how it intends to play: as a parochial competitor attempting to limit damage, as an advocate of new approaches, as an "insider" working to assure that the central effort serves the nation as well as possible, or something else. Natural organizational pressures may favor damage limitation, but that is probably quite suboptimal. For those near the center, the issues involve how much to share, how much to listen, and how to balance leadership and collaboration.

The third item reflects a recommendation that was made strongly by all of the workshop participants: if you are beginning with a "cold" intellectual base, it is particularly important to do general homework and data collection as early as possible. This point is discussed further below.

The fourth and fifth items suggest that it may be quite useful for QDR groups to anticipate alternative perspectives and issues and to sketch through alternative "story lines." This is in somewhat the same spirit as those who suggest starting with output and working backward. Here, however, we emphasize the need to contemplate *different* story lines with different issues and measures of merit. This concept is elaborated on in the following slide.

Assuring Range of Options: Recognizing Alternative Perspectives of What QDR Is About



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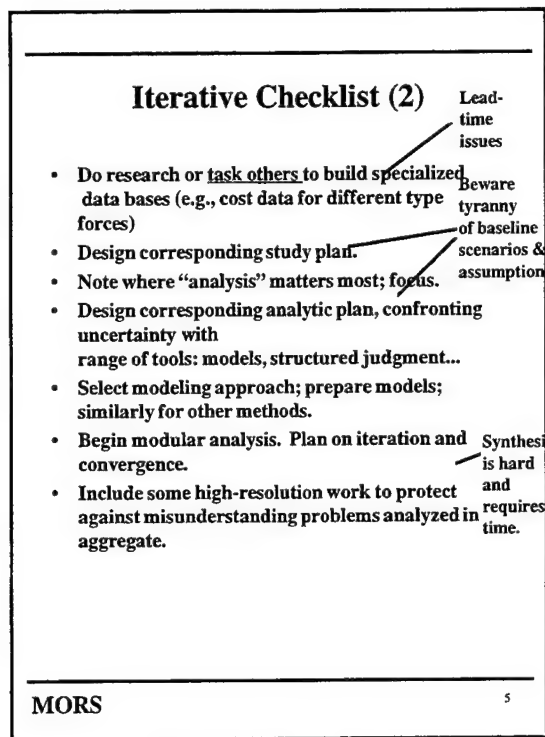
Assuring an adequate range of options is not so easy, but it helps a great deal to appreciate where different people are coming from as they enter the QDR or plan to critique it. At the center of the figure is a perspective that sees the current program as basically sound. Yes, significant changes are needed on the margin, as usual. More important, however, this perspective sees the primary challenge to be broadening, enriching, and explaining the program's rationale.

By contrast, at the bottom left we see a perspective that sees the DoD budget as much too rich, perhaps by 30-50%. Proponents of this view believe that it is obvious that the world is not particularly dangerous at this point and that the nation can afford to buy less insurance, using the funds for better purposes.

At the bottom right corner is a very different perspective, one characterized by deep concern about the prolonged procurement holiday and the very long service lifetimes being postulated for our capital base (e.g., aircraft, trucks, ships). Proponents see the need for more funding, primarily to replenish and modernize.

At the top is yet another perspective. This one is focused on the future of 10-15 years from now. It is concerned with what it sees as the obvious need for an across-the-board re-engineering, one that would at least help control costs (and might even permit a reduction of the overall budget), but in any case would restructure forces and doctrine for the next era of warfare.

Is it not clear that the "story lines" for a QDR report might be very different if undertaken by individuals with these various perspectives? The QDR itself, then, should anticipate all the perspectives, questions, and related measures.



Having done such story sketching, it should be possible to identify long-lead-time information that needs to be collected — either by the group itself or by tasking others. Some of the data does not exist and other data are jealously guarded and cannot be sprung loose without time, effort, and assurances about fair use. The next step is to translate the results into a study plan, one that encompasses the full range of issues. Here it is especially useful to notice where “analysis” is likely to be truly important to the quality of decisions, as distinct from being merely something that is “nice to do”. The point is to focus on issues where analysis will matter the most.

The next step is to design an analytic plan. Here we emphasize the need to confront uncertainty fully. This has assuredly not been standard practice in the past, but it seems critical now. Confronting uncertainty, however, requires a range of tools: a variety of models, both “objective” and “subjective” methods, and integrating devices.

Given a study plan and an analysis plan, it is time to worry about models and methods, and to then begin execution in a modular way. This is not unusual or even especially difficult. What in our experience *is* difficult is the subsequent synthesis: the “modules” turn out not to be quite what was expected, there are nonlinear complications, and one finds it necessary to iterate — sometimes going back to basics. Our suggestion, then, much like that of several plenary speakers, is to *plan* on iteration and convergence. Avoid plans that call for miraculous successful synthesis at the end of the process. Another key notion here is to start the iterative process with simple models and constructs, which are often better for such purposes than first-cut complex analyses.

Finally, we note that even though the QDR will probably rely primarily on low-resolution analysis, hopefully with substantial exploration of uncertainty, it is important to conduct selective in-depth analyses. That is because low-resolution analysis is usually guided by intuition that can on occasion be very wrong. High-resolution work may be inflexible and unreliable in many ways, but it may clarify what matters.

Resolving Critical Antinomies

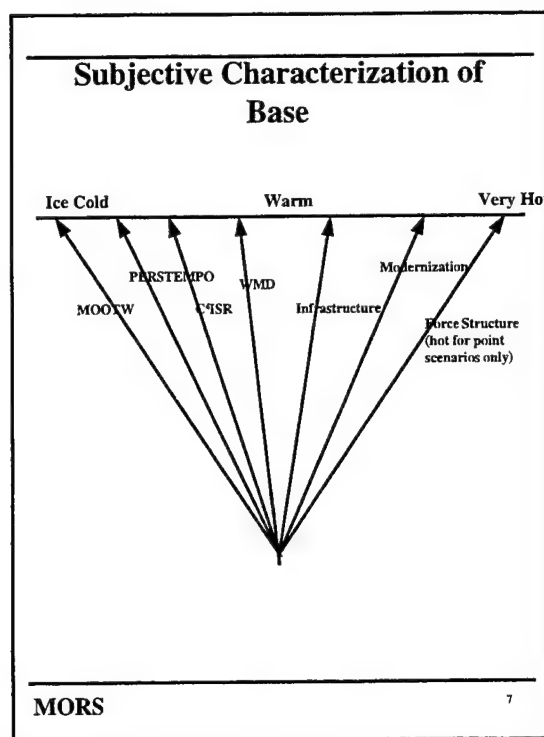
- **Quick vs. Deliberate**
 - Implement as successive QRAs of appropriate duration
 - Do not implement as single “big bang”
- **Normal vs. Radical**
 - For most issues, employ familiar tools but argue about scope, framing, and assumptions (deductive approach)
 - For important “new” or “special” issues (e.g., IW, asymmetric response, small-force operations), employ more creative approaches
- **Private vs. Public**
 - Recognize central analyses will be subject to extraordinary scrutiny; therefore, document and prepare audit trail accordingly
 - Still need private analyses to address specialized stakeholder concerns

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Several of the actions identified in the prior checklist suggest potential tensions. One of the plenary speakers, Will O’Neil, CNA, highlighted these tensions by identifying several critical antinomies. It was the consensus of the workshop participants that these antinomies should be resolved as follows:

- **Quick vs. Deliberate.** We recommend that the Quick Reaction Analyses (QRAs) be implemented as successive efforts of appropriate duration (e.g., a two week effort to identify the major issues, followed by four-to-eight week efforts to undertake more focused, in-depth analyses). Under *no* circumstances should one plan to undertake monolithic efforts that provide no flexibility to adaptively adjust activities to pursue key issues that emerge.
- **Normal vs. Radical.** Given the time constraints implicit in the QDR, there is limited opportunity to create, verify, validate, & accredit (VV&A), and become familiar with radical new tools. Consequently, we recommend that *appropriate*, familiar tools be employed for most issues. However, we urge that there be extensive discussion about such key factors as scope, framing of the problem (e.g., selection of Measures of Merit), and assumptions. For those issues for which no appropriate, familiar tools are available, we recommend that more creative approaches be employed (e.g., use of seminar wargames to illuminate Information Warfare (IW) or asymmetric responses).
- **Public vs. Private.** In view of the importance of the QDR to the defense community, it must be anticipated that central analyses will be subjected to extraordinary scrutiny. Thus, we recommend that resources be allocated to document and prepare an appropriate audit trail. However, it should be recognized that there is a role for private analyses to address specialized stakeholder concerns.

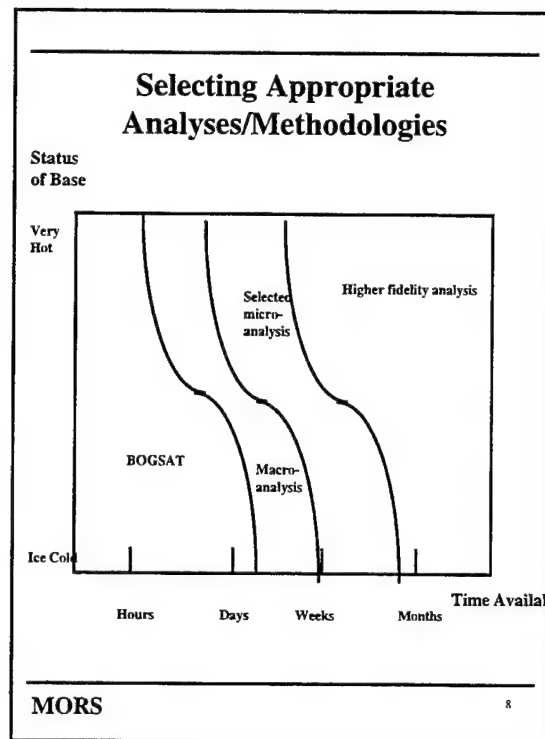


The mini-symposium included a good deal of discussion about how the ability to accomplish QRA depended on the quality of "the intellectual base" and how that varied substantially from subject area to subject area. Although this slide is enormously simplified, it summarizes our sense of what participants believed the situation to be. In particular, those concerned with military operations other than war (MOOTW), personnel tempo (PERSTEMPO), and C4ISR were articulate in decrying a very cold base and suggesting immediate ways to improve the situation.

For example, the MOOTW panel observed that there were basic disagreements over an appropriate MOOTW typology and noted that only preliminary efforts are underway to identify the requirements for tools to support analyses of MOOTW issues.

Conversely, the workshop members noted that there was a great deal of individual Service information on PERSTEMPO. However, due to Service differences in Measures of Merit, standards, and data elements, it would require a concerted effort to normalize this information to characterize the problem from a joint perspective.

Finally, in the area of C4ISR, it has long been recognized that it is exceedingly difficult to assess the impact of C4ISR on mission effectiveness. However, the on-going C4ISR Mission Assessment is attempting to assemble key data and tools to improve this capability.



Each panel was asked to identify the appropriate analyses/methodologies to cope with their subject area as a function of the status of the intellectual base and the time available to perform the analyses. The accompanying nomograph was developed to summarize the results of those panels. Note that the abscissa employs a logarithmic scale.

It can be seen that the panelists generally called for four different classes of tools. When time is exceedingly short (e.g., hours), the best one can do is rely on a “bunch of guys sitting around a table (BOGSAT)” to elicit informed opinion. If the intellectual base is ice cold, it may take several days to even identify and assemble a set of knowledgeable individuals.

If more time is available, it is feasible to perform macroanalyses. If the base is hot, this can be done by drawing on existing studies and tools to generate results within a day or so. For cold bases, that time can extend to weeks and may be restricted to structured, subjective analyses.

As time increases, it makes it feasible to address *selected* issues in greater depth. Note that the times involved are very sensitive to the “warmth” of the intellectual base.

Finally, if several weeks or months are available, it becomes feasible to perform higher fidelity analyses drawing on modeling and simulation tools that have been developed over extended periods of time.

In general, it was concluded, that there is considerable leverage in taking initial steps to “warm up” a “cold” intellectual base to better position the community for future QDRs.

**Selected Working Group
Observations:
Process/Methodology**

- **Adopt RAND framework, even if**
 - Work is of very short duration
 - Not all data are available
 - Not all models are feasible
- **Government offices should immediately begin QDR drills (e.g., 2 week efforts), starting the iterative process**
- **MORS should collect information on on-going studies for dissemination**
- **Credible cost vs capability trades can not be resolved in weeks**

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In talking about the QDR, the working groups made several observations to guide near term actions. These observations have been subdivided into the categories of process/methodology and substance (see next slide).

In the category of process/methodology, there was a consensus that there was value in adopting the RAND framework*, even if work is of very short duration, not all data are available, and not all models are feasible.

Second, it was recommended that government offices should immediately begin QDR drills (e.g., two week efforts). Such drills should be viewed as preliminary efforts to identify critical issues and to identify voids in intellectual tools or data. These activities would be the initial steps in a continuing, iterative process.

Third, to assist the community, MORS should collect information on on-going studies for dissemination. These efforts should be focused on those areas where the QDR drills reveal critical voids.

Finally, it was cautioned that credible cost vs capability trades can not be resolved in weeks. Thus it is imperative to begin them early and iteratively attack the problem.

* As described in "Adaptiveness in National Defense: The Basis of a New Framework", Paul K. Davis, David Gompert, Richard Kugler, RAND Issue Paper, August 1996.

Selected Working Group Observations: Substance

- **We need much more attention on**
 - The “Now MRC” issue
 - Below-the-line-forces (the line is blurring)
- **For force structure and infrastructure issues:**
 - Draw explicit connections
 - Coordinate drawdowns
- **Infrastructure issues should be assessed for effects on**
 - Environment shaping
 - Strategic adaptiveness

**Overall: Simplicity and coherence
are essential**

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In the “substance” category, the working groups made the following observations.

First there are several areas that require much more attention. These include increased consideration of the “Now MRC” (to use the phrase introduced by MG Hamilton) and below-the-line-forces (e.g., C4ISR).

Second, it was observed that there is inadequate understanding of the relationship between key major issue areas. For example, there is a need to draw explicit connections between force structure and infrastructure issues and to coordinate drawdowns between them.

Third, the RAND paper cited above introduced the criteria of environment shaping and strategic adaptiveness. It is recommended that infrastructure issues should be assessed with respect to those criteria.

Overall, it was emphasized that simplicity and coherence in analysis are essential if analysts are to serve the needs of decisionmakers adequately.

Recommendation: Integrative Frameworks

- **Finding: need for integrating frameworks**
 - Macro-frameworks to create balance and highlight tradeoffs (e.g., more capability for MRCs vs. more overseas presence)
 - Micro-frameworks to help focus "cold" or fragmented knowledge bases (e.g., PERSTEMPO, OOTW, IW)
 - Special cross-cutting frameworks (e.g., for unusual tradeoffs such as PGMs vs. end strength)
- **Recommendations**
 - Macro-frameworks: Embrace or formulate frameworks facilitating both decomposition and meaningful synthesis (OSD/JS)
 - Micro-frameworks: Create immediately for areas with "cold" bases (OSD/JS)
 - Special frameworks to enrich trade space: Create money-pot with postulated cuts of, e.g., infrastructure and end strength (OSD); then make tradeoffs across categories (OSD)

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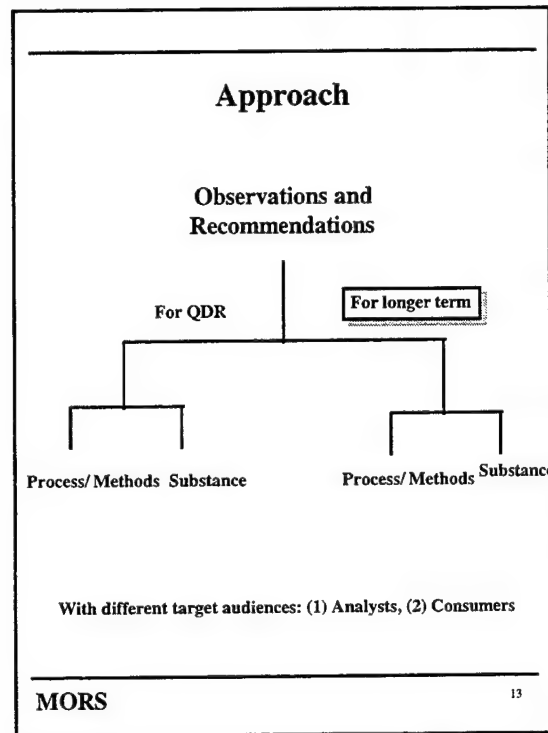
Our next recommendation involves the need for integrative frameworks. It was clear from the mini-symposium discussion that in some domains the quality of analysis suffers greatly from fragmentation of concepts, measures, and perspectives. We need integrating frameworks. As noted above, the mini-symposium included discussion of the RAND macro-framework, for which there was strong support, but there seems to be more of a vacuum in talking about micro-frameworks (e.g., PERSTEMPO, OOTW, and IW). We also do not have agreements on diverse, cross-cutting tradeoff frameworks that would help us make trades that we "know" should be considered, but which cut across category barriers in uncomfortable ways. The recommendation, then, is for OSD and the Joint Staff to move to get such frameworks created. More on this later.

Recommendation on Dealing With Uncertainty

- **Background:** Bill Lynn's first challenge to MORS: "uncertainty of dominant military threats in the future"
- **Recommendation:**
 - Portfolio approach, with expectation of adjustments over time
 - Scenario-space testing of contingency capabilities
 - Deemphasis of alleged best-estimate baselines in favor of exploratory analysis
 - Value of (fractional) factorial experimental design
 - Accept and exploit disciplined subjective methods where needed (e.g., as in adjusting portfolio balance)

This slide is a QDR-specific recommendation responding directly to the first concern expressed by the Director for Program Analysis and Evaluation, Bill Lynn, in his plenary address. The issue: how to cope with uncertainty in the absence of a dominant threat. The answer, we believe, is to take a portfolio-management approach looking at defense more broadly than merely preparing for standardized MRCs. The RAND approach (cited above), for which there was broad support, suggests a portfolio with components for operational adaptiveness in diverse contingencies, environment shaping, and strategic adaptiveness.

Another part of the answer is to confront uncertainty within each component, e.g., with "scenario-space" methods and "exploratory analysis" of contingencies, or by assessing environment shaping and strategic adaptiveness from different perspectives. To be efficient and disciplined, it is recommended that fractional factorial experimental designs be employed to explore the scenario-space systematically. Such assessments must be subjective, but they can nonetheless be disciplined and understandable.



During the course of the workshop deliberations, it was pointed out that a QDR will, in fact, recur every four years. Hence there was some discussion about what might be done to prepare for the longer term. The remainder of this briefing focuses on these recommended actions.

Observations and Recommendations for Longer Term

- **Observation: problems leading to QRAM conference involve two frustrated parties:**
 - Consumers who can't get relevant, high quality, quick reaction analysis (QRA)
 - Analysts who feel they are being asked to do shoddy or impossible work
- **Observation: it's a systems problem**
- **Recommendation: Establish "contract" between analysts and consumers**

Our first observation here is that the mini-symposium was called because there were perceived problems related to two frustrated parties: the analyst community and the community of analysis consumers. The consumers have become increasingly annoyed at the difficulties encountered in obtaining quick-response analysis to a wide range of questions with a wide range of assumptions. Too often they have been told, "We can't do that in less than six months and, even then, we can only work two cases." At the same time, the analyst community has often been frustrated by highly episodic support (by which we mean that support is often minimal except when a firedrill seems imminent) and demands that seem unreasonable given the realities of such factors as models, data bases, and coordination. There are many dimensions to the two sides' frustrations, but what seemed to us most interesting is that the situation is in fact a prime example of *a systems problem*, the very kind of thing analysts like. Without elaborating on the complexities of the problem, let us instead mention our bottom line — a kind of "modest proposal." We suggest that the two communities enter into a new "contract."

Preface to Contract

An important *image*:

- QRA is a *process*, populated with educated, trained, and informed people, dedicated to disciplined, scientific thought in organizations that foster aggressive pursuit of "truth."
- But pursuit of truth is served by healthy competition, and even advocacy, of ideas.

Before describing the contract we envision, let us mention a vision of quick reaction analysis (QRA) — a normative vision to be sure, but one to be taken seriously. The slide speaks for itself.

What Analytic Community Should Stipulate and Promise

Stipulations

- High-quality QRA is quite feasible, given warm base.
- Analysis often requires mix of “objective” and “subjective” tools; both can be disciplined (i.e., clear and logical audit trail).
- Confronting uncertainty is more important than optimizing artificially.
- “Large” analysis and modeling projects should add substantially to enduring knowledge base.

Promises We shall:

- Create and maintain the warm, rich base needed.
- Practice for QRAs -- we shall be ready.
- Enlarge our bag of tools to include families of models, subjective methods, and integrating frameworks useful to policy makers.
- Seek “rigor” in all of the analysis, not just mathematics.
- Document and disseminate our work for peer review, comparison, and iteration.

What would the analytic community be stipulating and agreeing in a contract? This slide summarizes what we see as the most salient issues. First, the community needs to accept that QRA can be of high quality, and is certainly of great importance. There is no conflict with integrity in doing QRA—so long as there is a warm enough base of expertise, or enough time to build an adequate base for the purposes at hand. Second, the community needs to embrace and improve subjective methods, because they are necessary for much of the most important analysis. Although its form of “rigor” is different than that of physics, and we use the term “disciplined” to make this point, it can be quite respectable. Third, there needs to be general acceptance that confronting uncertainty (and multiple dimensions of problems) is more important in policy-level work than seeking some hypothetical “optimization,” behind which there is inevitably a long list of narrow and dubious assumptions. Since operations researchers are often trained to optimize, and since there is some “security” in not straying too far from approved baseline cases and standard methods, this stipulation is nontrivial. Finally, we believe it important for the community to recognize that when funding *is* made available for large studies or analytical efforts, there is an obligation to leave a legacy — to leave an improved knowledge base that will endure. Turning in viewgraphs is not enough.

The stipulations are the hard part. The promises shown are perhaps straightforward next steps, except for the last item, which we believe is crucial in establishing quality and in disseminating the knowledge gained. The community should promise to promote openness, peer review, comparison, and iteration. This would mean big changes in the defense analytic community, as would the other promises.

What the Consumers Should Stipulate and Promise

Stipulations

- Issues are seldom resolved in any one cycle; issues will be revisited.
- Thus, investments in research and improved methods are worthwhile.
- Knowledge base matters greatly. Current base is inadequate for new issues. We need investments in (1) empirical and theoretical research, (2) families of models and diverse tools.
- Standardized, negotiated assumptions can be stifling and counterproductive; we need broad uncertainty analyses and diversity of views.
- Analyses and underlying tools should be documented and disseminated appropriately. Openness improves quality.

Promises We shall:

- Support creating and maintaining a strong base.
- Support documenting, appropriate publishing, comparing, and iterating.
- Temper efforts to eliminate redundancy by positively encouraging parallel analyses and alternative models (support marketplace of ideas).

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But what would the analysts seek in return? Here we suggest what the consumers might stipulate and promise. First, they should recognize that the world does not stop at the end of the QDR. There will in fact be many revisits of nearly all the important issues. There will be more QDRs. It follows that there is no excuse for not investing in research and methods: research to improve the knowledge base, and methods to improve our ability to represent knowledge and analyze tough issues. Yes, some of the work will take years to accomplish. Perhaps the item about the knowledge base being important seems obvious, but we believe that our current knowledge base is simply not adequate to support the decisions being made. We are entering a new era of warfare.

The next item may be a bitter pill. It seems evident to us, however, and to most attendees if we judge sentiments correctly, that the government consumers have sometimes created difficulties by attempting to be maximally responsive. They have so emphasized development of agreed baselines, which are undeniably valuable, as to suppress and discourage the exploration of uncertainty and alternative views (e.g, on doctrinal concepts). The synthesis here is to seek multiple baselines rather than overvaluing any single one, and to insist upon exploratory analysis, by which we mean far more than modest sensitivity analyses. The consumers also should stipulate to the importance of documentation, publication, peer review, and the general marketplace of ideas.

The promises? Those would focus primarily on providing stable funding for the creation and continual improvement of the knowledge base and methods. This links, of course, to the promise of the analytic community to use this funding responsibly.

Measures of Merit and Related Matters

Observation

- Every plenary speaker highlighted the problem of Measure of Merit (MoM) selection
- But, the issue is broader

Recommendation

- Convene MORS mini-symposium to discuss, debate, and characterize “best practices” with respect to paradigms, frameworks, and hierarchical MoMs
- Address in both breadth and depth, e.g.,
 - Strategic frameworks (e.g., portfolio structures)
 - Taxonomies (e.g., strategies to tasks)
 - Costing and tradeoff frameworks
 - Wars, campaigns, operations, tasks, performance, ...

This slide responds to a recurrent theme throughout the mini-symposium, that developing the “right” measures of merit is very important, but treacherously difficult. Upon reflection we conclude that MORS has a role here. We suggest that the sponsors request MORS to convene a mini-symposium. However, we have in mind something that goes well beyond “MoEs.” We believe it should address paradigms, frameworks, and entire hierarchies of measures of merit — all in the same forum. Why? Because we are in a new era that requires fundamental changes of perspective and learning new ways to organize and communicate. There are many excellent ideas in the community already, and some of these could be identified as corresponding to “best practices.” In other cases, we need the debates and new ideas. Also, we can strongly benefit from the cross-fertilization. We are in an era that seems to require more interdisciplinary work than previously (e.g., more attention to costs as well as effectiveness, and explicit coupling of proposals on force structure and infrastructure). Further, we are in an era that should demand that analysts be familiar with paradigms, frameworks, and MoMs at different levels of resolution and from different perspectives. MORS could help in the process of making this happen.

Questionable Paradigms, Frameworks, MOMS

Force Structure

- Traditional: Force structure = {DEs, wings, CVBGs, MEFs}
- Issues: Are these the right piece parts? How do we assess the whole?

Logistics

- Traditional: ton-miles per day
- Issue: Does this obfuscate discriminate delivery at the right time?

Balance

- Traditional: tooth-to-tail ratio
- Issue: Does this oversimplify? Do we need more "body parts"?

This slide gives examples of where measures need to be rethought. The first reflects an observation from the plenary by Paul Davis. The second and third reflect comments by Major General Mark Hamilton, J8, Joint Staff, in his plenary presentation.

Summary

- **For the QDR**
 - In key areas, the analytic community is inadequately prepared for the QDR
 - Over the next 2 months, the analytic community can enhance its readiness substantially by
 - “Warming up” the intellectual base in key areas (e.g., MOOTW, PERSTEMPO)
 - Performing preparatory “two week drills”, consistent with the Check List recommendations
- **For the longer term**
 - Once the QDR is over, we must take steps to prepare for future QDRs (i.e., achieve real “lessons learned” vice “lessons recorded”)
 - The proposed “analyst/consumer” contract lays out a rational plan of attack

To summarize the deliberations of the Synthesis Panel, we offer observations and recommendations in two key areas.

With respect to the QDR, we observe that in several key areas (e.g., MOOTW, PERSTEMPO) the analytic community is inadequately prepared. To ameliorate that shortfall we recommend that several steps be taken over the next two months. First, in those areas for which the intellectual base is coldest, we recommend that steps be taken to warm up the base (e.g., agree on Measures of Merit, standards, definitions, and begin to assemble critically needed data). Second, we recommend that preparatory two week drills be performed within and across key areas. At a minimum, these would serve to identify the major issues that are likely to be the focus of the QDR.

With respect to the longer term, we recommend that once this iteration of the QDR is over, we must take steps to prepare for future QDRs. This requires going beyond merely recording lessons from the QDR, but truly learning from it. We recommend that serious consideration be given to implement the draft analyst/consumer contract included in this report to establish a rational plan of attack. Only then will we have a firm foundation upon which to build the tools, data, and procedures needed to sustain sound, creative defense analyses that are responsive to the needs of the decision maker.

**Appendix A1 – 1997 DoD Conference Report – “The Military Force
Structure Review Act of 1996”**

Subtitle B--Force Structure Review

SEC. 921. SHORT TITLE.

This subtitle may be cited as the 'Military Force Structure Review Act of 1996'.

SEC. 922. FINDINGS.

Congress makes the following findings:

(1) Since the collapse of the Soviet Union in 1991, the United States has conducted two substantial assessments of the force structure of the Armed Forces necessary to meet United States defense requirements.

(2) The assessment by the Bush Administration (known as the 'Base Force' assessment) and the assessment by the Clinton Administration (known as the 'Bottom-Up Review') were intended to reassess the force structure of the Armed Forces in light of the changing realities of the post-Cold War world.

(3) Both assessments served an important purpose in focusing attention on the need to reevaluate the military posture of the United States, but the pace of global change necessitates a new, comprehensive assessment of the defense strategy of the United States and the force structure of the Armed Forces required to meet the threats to the United States in the twenty-first century.

(4) The Bottom-Up Review has been criticized on several points, including--

(A) the assumptions underlying the strategy of planning to fight and win two nearly simultaneous major regional conflicts;

(B) the force levels recommended to carry out that strategy; and

(C) the funding proposed for such recommended force levels.

(5) In response to the recommendations of the Commission on Roles and Missions of the Armed Forces, the Secretary of Defense endorsed the concept of conducting a quadrennial review of the defense program at the beginning of each newly elected Presidential administration, and the Department intends to complete the first such review in 1997.

(6) The review is to involve a comprehensive examination of defense strategy, the force structure of the active, guard, and reserve components, force modernization plans, infrastructure, and other elements of the defense program and policies in order to determine and express the defense

strategy of the United States and to establish a revised defense program through the year 2005.

(7) In order to ensure that the force structure of the Armed Forces is adequate to meet the challenges to the national security interests of the United States in the twenty-first century, to assist the Secretary of Defense in conducting the review referred to in paragraph (5), and to assess the appropriate force structure of the Armed Forces through the year 2010 and beyond (if practicable), it is important to provide for the conduct of an independent, nonpartisan review of the force structure that is more comprehensive than prior assessments of the force structure, extends beyond the quadrennial defense review, and explores innovative and forward-thinking ways of meeting such challenges.

SEC. 923. QUADRENNIAL DEFENSE REVIEW.

(a) Requirement in 1997: The Secretary of Defense, in consultation with the Chairman of the Joint Chiefs of Staff, shall complete in 1997 a review of the defense program of the United States intended to satisfy the requirements for a Quadrennial Defense Review as identified in the recommendations of the Commission on Roles and Missions of the Armed Forces. The review shall include a comprehensive examination of the defense strategy, force structure, force modernization plans, infrastructure, budget plan, and other elements of the defense program and policies with a view toward determining and expressing the defense strategy of the United States and establishing a revised defense program through the year 2005.

(b) Involvement of National Defense Panel: (1) The Secretary shall apprise the National Defense Panel established under section 924, on an ongoing basis, of the work undertaken in the conduct of the review.

(2) Not later than March 14, 1997, the Chairman of the National Defense Panel shall submit to the Secretary the Panel's assessment of work undertaken in the conduct of the review as of that date and shall include in the assessment the recommendations of the Panel for improvements to the review, including recommendations for additional matters to be covered in the review.

(c) Assessments of Review: Upon completion of the review, the Chairman of the Joint Chiefs of Staff and the Chairman of the National Defense Panel, on behalf of the Panel, shall each prepare and submit to the Secretary such chairman's assessment of the review in time for the inclusion of the assessment in its entirety in the report under subsection (d).

(d) Report: Not later than May 15, 1997, the Secretary shall submit to the Committee on Armed Services of the Senate and the Committee on National Security of the House of Representatives a comprehensive report on the review. The report shall include the following:

(1) The results of the review, including a comprehensive discussion of the defense strategy of the United States and the force structure best suited to implement that strategy.

(2) The threats examined for purposes of the review and the scenarios developed in the examination of such threats.

(3) The assumptions used in the review, including assumptions relating to the cooperation of allies and mission-sharing, levels of acceptable risk, warning times, and intensity and duration of conflict.

(4) The effect on the force structure of preparations for and participation in peace operations and military operations other than war.

(5) The effect on the force structure of the utilization by the Armed Forces of technologies anticipated to be available by the year 2005, including precision guided munitions, stealth, night vision, digitization, and communications, and the changes in doctrine and operational concepts that would result from the utilization of such technologies.

(6) The manpower and sustainment policies required under the defense strategy to support engagement in conflicts lasting more than 120 days.

(7) The anticipated roles and missions of the reserve components in the defense strategy and the strength, capabilities, and equipment necessary to assure that the reserve components can capably discharge those roles and missions.

(8) The appropriate ratio of combat forces to support forces (commonly referred to as the 'tooth-to-tail' ratio) under the defense strategy, including, in particular, the appropriate number and size of headquarter units and Defense Agencies for that purpose.

(9) The air-lift and sea-lift capabilities required to support the defense strategy.

(10) The forward presence, pre-positioning, and other anticipatory deployments necessary under the defense strategy for conflict deterrence and adequate military response to anticipated conflicts.

(11) The extent to which resources must be shifted among two or more theaters under the defense strategy in the event of conflict in such theaters.

(12) The advisability of revisions to the Unified Command Plan as a result of the defense strategy.

(13) Any other matter the Secretary considers appropriate.

SEC. 924. NATIONAL DEFENSE PANEL.

(a) Establishment: Not later than December 1, 1996, the Secretary of Defense shall establish a nonpartisan, independent panel to be known as the National Defense Panel (in this section referred to as the 'Panel'). The Panel shall have the duties set forth in this section.

(b) Membership: The Panel shall be composed of a chairman and eight other individuals appointed by the Secretary, in consultation with the chairman and ranking member of the Committee on Armed Services of the Senate and the chairman and ranking member of the Committee on National Security of the House of Representatives, from among individuals in the private sector who are recognized experts in matters relating to the national security of the United States.

(c) Duties: The Panel shall--

(1) conduct and submit to the Secretary the assessment of the review under section 923 that is required by subsection (b)(2) of that section;

(2) conduct and submit to the Secretary the comprehensive assessment of the review that is required by subsection (c) of that section upon completion of the review; and

(3) conduct the assessment of alternative force structures for the Armed Forces required under subsection (d).

(d) Alternative Force Structure Assessment: (1) The Panel shall submit to the Secretary an independent assessment of a variety of possible force structures of the Armed Forces through the year 2010 and beyond, including the force structure identified in the report on the review under section 923(d). The purpose of the assessment is to develop proposals for an 'above the line' force structure of the Armed Forces and to provide the Secretary and Congress recommendations regarding the optimal force structure to meet anticipated threats to the national security of the United States through the time covered by the assessment.

(2) In conducting the assessment, the Panel shall examine a variety of potential threats (including near-term threats and long-term threats) to the national security interests of the United States, including the following:

(A) Conventional threats across a spectrum of conflicts.

(B) The proliferation of weapons of mass destruction and the means of delivering such weapons, and the illicit transfer of technology relating to such weapons.

(C) The vulnerability of United States technology to nontraditional threats, including information warfare.

(D) Domestic and international terrorism.

(E) The emergence of a major potential adversary having military capabilities similar to those of the United States.

(F) Any other significant threat, or combination of threats, identified by the Panel.

(3) For purposes of the assessment, the Panel shall develop a variety of scenarios requiring a military response by the United States, including the following:

(A) Scenarios developed in light of the threats examined under paragraph

(B) Scenarios developed in light of a continuum of conflicts ranging from a conflict of lesser magnitude than the conflict described in the Bottom-Up Review to a conflict of greater magnitude than the conflict so described.

(4) As part of the assessment, the Panel shall also--

(A) develop recommendations regarding a variety of force structures for the Armed Forces that permit the forward deployment of sufficient air, land, and sea-based forces to provide an effective deterrent to conflict and to permit a military response by the United States to the scenarios developed under paragraph (3);

(B) to the extent practicable, estimate the funding required by fiscal year, in constant fiscal year 1997 dollars, to organize, equip, and support the forces contemplated under the force structures assessed in the assessment; and

(C) comment on each of the matters also to be included by the Secretary in the report required by section 923(d).

(e) Report: (1) Not later than December 1, 1997, the Panel shall submit to the Secretary a report setting forth the activities and the findings and recommendations of the Panel under subsection (d), including any recommendations for legislation that the Panel considers appropriate.

(2) Not later than December 15, 1997, the Secretary shall, after consultation with the Chairman of the Joint Chiefs of Staff, submit to the committees referred to in subsection (b) a copy of the report under paragraph (1), together with the Secretary's comments on the report.

(f) Information From Federal Agencies: The Panel may secure directly from the Department of Defense and any of its components and from any other Federal department and agency such information as the Panel considers necessary to carry out its duties under this section. The head of the department or agency concerned shall ensure that information requested by the Panel under this subsection is promptly provided.

(g) Personnel Matters: (1) Each member of the Panel shall be compensated at a rate equal to the daily equivalent of the annual rate of basic pay prescribed for level IV of the Executive Schedule under section 5315 of title 5, United States Code, for each day (including travel time) during which such member is engaged in the performance of the duties of the Panel.

2) The members of the Panel shall be allowed travel expenses, including per diem in lieu of subsistence, at rates authorized for employees of agencies under subchapter I of chapter 57 of title 5, United States Code, while away from their homes or regular places of business in the performance of services for the Panel.

(3)(A) The chairman of the Panel may, without regard to the civil service laws and regulations, appoint and terminate an executive director, and a staff of not more than four additional individuals, if the Panel determines that an executive director and staff are necessary in order for the Panel to perform its duties effectively. The employment of an executive director shall be subject to confirmation by the Panel.

(B) The chairman may fix the compensation of the executive director without regard to the provisions of chapter 51 and subchapter III of chapter 53 of title 5, United States Code, relating to classification of positions and General Schedule pay rates, except that the rate of pay for the executive director may not exceed the rate payable for level V of the Executive

Schedule under section 5316 of such title.

(4) Any Federal Government employee may be detailed to the Panel without reimbursement, and such detail shall be without interruption or loss of civil service status or privilege. The Secretary shall ensure that sufficient personnel are detailed to the Panel to enable the Panel to carry out its duties effectively.

(5) To the maximum extent practicable, the members and employees of the Panel shall travel on military aircraft, military ships, military vehicles, or other military conveyances when travel is necessary in the performance of a duty of the Panel, except that no such aircraft, ship, vehicle, or other conveyance may be scheduled primarily for the transportation of any such member or employee when the cost of commercial transportation is less expensive.

(h) Administrative Provisions: (1) The Panel may use the United States mails and obtain printing and binding services in the same manner and under the same conditions as other departments and agencies of the Federal Government.

(2) The Secretary shall furnish the Panel any administrative and support services requested by the Panel.

(3) The Panel may accept, use, and dispose of gifts or donations of services or property.

(i) Payment of Panel Expenses: The compensation, travel expenses, and per diem allowances of members and employees of the Panel shall be paid out of funds available to the Department of Defense for the payment of compensation, travel allowances, and per diem allowances, respectively, of civilian employees of the Department. The other expenses of the Panel shall be paid out of funds available to the Department for the payment of similar expenses incurred by the Department.

(j) Termination: The Panel shall terminate 30 days after the date on which the Panel submits its report to the Secretary under subsection (e).

SEC. 925. POSTPONEMENT OF DEADLINES.

If the Presidential election in 1996 results in the election of a new President, each deadline set forth in this subtitle shall be postponed by three months.

SEC. 926. DEFINITIONS.

In this subtitle:

(1) The term 'above the line' force structure of the Armed Forces' means the force structure (including numbers, strengths, and composition and major items of equipment) for the Armed Forces at the following unit levels:

(A) In the case of the Army, the division.

(B) In the case of the Navy, the battle group.

(C) In the case of the Air Force, the wing.

(D) In the case of the Marine Corps, the expeditionary force.

(E) In the case of special operations forces of the Army, Navy, or Air Force, the major operating unit.

(F) In the case of the strategic forces, the ballistic missile submarine fleet, the heavy bomber force, and the intercontinental ballistic missile force.

(2) The term 'Commission on Roles and Missions of the Armed Forces' means the Commission on Roles and Missions of the Armed Forces established by subtitle E of title IX of the National Defense Authorization Act for Fiscal Year 1994 (Public Law 103-160; 107 Stat. 1738; 10 U.S.C. 111 note).

(3) The term 'military operation other than war' means any operation other than war that requires the utilization of the military capabilities of the Armed Forces, including peace operations, humanitarian assistance operations and activities, counter-terrorism operations and activities, disaster relief activities, and counter-drug operations and activities.

(4) The term 'peace operations' means military operations in support of diplomatic efforts to reach long-term political settlements of conflicts and includes peacekeeping operations and peace enforcement operations.

Subtitle B--Force Structure Review

LEGISLATIVE PROVISIONS ADOPTED

Force Structure Review (secs. 921-926)

The Senate amendment contained a number of provisions (secs. 1091-1096) in subtitle G of title 10, referred to as the 'Armed Forces Force Structure Review Act of 1996.' This Act would require the Secretary of Defense, in

consultation with the Chairman of the Joint Chiefs of Staff, to conduct a Quadrennial Defense Review (QDR) as recommended by the Commission on Roles and Missions of the Armed Forces. This review would be a complete re-examination of the defense strategy, force structure, force modernization plans, budget plans, infrastructure, and other elements of the defense program and policies with a view toward determining and expressing the defense strategy of the United States, and establishing a national defense program, as we enter the 21st Century.

In carrying out this review, the Department would examine the potential near- and long-term threats to U.S. national security including:

- (a) the proliferation of weapons of mass destruction and the means to deliver them;
- (b) conventional threats across a spectrum of conflicts;
- (c) the vulnerability of our information systems and other advanced technologies to non-traditional threats;
- (d) domestic and international terrorism; and
- (e) the potential emergence of a major adversary.

The Act would also create an independent, non-partisan panel of defense experts (to be known as the National Defense Panel) that would provide the Secretary of Defense and the Congress alternative recommendations regarding the optimal force structure required to meet the national security needs of the United States. This panel would be appointed by the Secretary of Defense after consultation with the Chairmen and Ranking Members of the Committee on Armed Services of the Senate and the Committee on National Security of the House of Representatives.

The creation of the National Defense Panel is intended to help ensure the validity of the process by playing a very active role in reviewing and commenting on the QDR from the early stages of its development. The Panel is designed to provide the Congress, and the Secretary of Defense, with an independent review of the national security requirements of the United States, including the force structure necessary to meet those requirements. This will, hopefully, allow the Congress and the Secretary to consider alternative options when making decisions affecting the security of the United States.

Upon completion of the QDR, the Act would require that the Chairman of the Joint Chiefs of Staff and the Chairman of the National Defense Panel

prepare and submit to the Secretary of Defense, for inclusion in the Secretary's report to the Congress, their assessment of the QDR. The Secretary's report would also include a comprehensive discussion of the defense strategy of the United States, and the assumptions regarding the threats to our national security, mission sharing, levels of acceptable risk, warning times, and intensity and duration of the conflict. In addition, the report would address the effect on the force structure of preparations for, and participation in, peace operations and military operations other than war. It also would require a discussion of the effects which emerging technologies will have on the U.S. force structure and a number of other matters.

The House bill contained no similar provision.

The House recesses.

The conferees believe this is an appropriate time to review the strategy and force structure necessary to protect the interests of the United States in any future conflict. The pace of global change requires that the United States reexamine its military capabilities with a view toward preparing the military services for the 21st Century.

LEGISLATIVE PROVISIONS ADOPTED

SEC. 270. ANNUAL JOINT WARFIGHTING SCIENCE AND TECHNOLOGY PLAN.

(a) Annual Plan Required: On March 1 of each year, the Secretary of Defense shall submit to the Committee on Armed Services of the Senate and the Committee on National Security of the House of Representatives a plan for ensuring that the science and technology program of the Department of Defense supports the development of the future joint warfighting capabilities identified as priority requirements for the Armed Forces. (b) First Plan: The first plan under subsection (a) shall be submitted not later than March 1, 1997.

Appendix A2 – Biographies of Presentation Speakers

William J. Lynn III
Director, Program Analysis and Evaluation
Office of the Secretary of Defense

William J. Lynn currently serves as the Director for Program Analysis and Evaluation in the Office of the Secretary of Defense. In this capacity, he is responsible for advising the Secretary on program, budget and financial matters. Previously, he served as an Assistant to the Secretary of Defense for Budget. He was a Deputy Director of the Clinton-Gore Defense Department Transition Team, and a defense advisor to the Clinton-Gore Campaign.

From 1987 until 1993, Mr. Lynn was on the staff of Senator Edward M. Kennedy (D-Massachusetts) as the legislative counsel for defense and arms control matters and his staff representative on The Senate Armed Services Committee. Prior to 1987, he was a Senior Fellow in the Strategic Concepts Development Center at the National Defense University, where he specialized in strategic nuclear forces and arms control issues. He also was on the professional staff of the Institute for Defense Analyses. From 1982 to 1985, he served as the Executive Director of the Defense Organization Project at the Center for Strategic and International Studies (CSIS).

Mr. Lynn is a graduate of Dartmouth College (1976), has a JD from Cornell Law School (1980) and Masters in Public Affairs from the Woodrow Wilson School of Princeton University (1982). His publications include *Toward a More Effective Defense* (Ballinger, 1985) and articles in *International Security*, the *Yale Law and Policy Review*, *The New York Times*, and *The Los Angeles Times*.

William D. O'Neil
Vice President and Director
Requirements and Advanced Systems Division
Center for Naval Analyses

CNA Assignments

Vice President and Director, Requirements and Advanced Systems Division

Other Experience

Director, ASW Systems Center, Lockheed Corporation

Corporate Director of Strategic Planning, Lockheed Corporation

Chief Engineer — ATF System Engineering, Lockheed Aeronautical Systems Company. Directed systems engineering for F-22 Advanced Tactical Fighter Dem/Val.

Director, Planning and Requirements, Lockheed Aero Systems Company.

Assistant Deputy Under Secretary of Defense (Naval Warfare and Mobility), Office of Under Secretary of Defense (Research and Engineering (USDRE).

Technical/management oversight over all R&D and acquisition for tactical naval warfare, airlift, and sealift.

Staff specialist for Naval Vehicles and Sea Control Systems, Office of Director of Defense Research and Engineering (DDR&E). Technical management oversight of R&D for a variety of naval programs.

Operations research analyst, Office of Program Appraisal, Secretary of the Navy staff. Analyst/advisor on technology programs.

Operations research analyst/engineer in defense industry.

Naval reserve surface warfare officer (active duty 1960-1964).

Programmer, Hughes Aircraft.

Education

MS, Quantitative Methods, University of California, Los Angeles (UCLA), 1968

AB, Mathematics, UCLA, 1960

Advanced Studies in Systems Engineering and Applied Mathematics, UCLA, 1962-65, 1968-69

Honors and Professional Affiliations

Navy Meritorious Service Medal, 1989; Presidential Rank of Meritorious Senior Executive, 1983; DoD Meritorious Civilian Service Medal, 1980; Murray Lesch Memorial Prize in Management Service, 1968; Beta Gamma Sigma honor fraternity, 1967; Honor Graduate Award, Navy OCS, 1960; Acoustical Society of America; Institute of Electrical and Electronics Engineers; INFORMS; Military Operations Research Society; US Naval Institute; Naval Submarine League.

Dr. James P. Ignizio
Department of Systems Engineering
University of Virginia

Dr. James P. Ignizio received his PhD in Operations Research and Industrial Engineering from Virginia Tech. He is presently Professor, Department of Systems Engineering, the University of Virginia. He has taught previously at the University of Houston, the Pennsylvania State University and the University of Alabama in Huntsville. From 1962 through 1967, he directed several research and development efforts in the aerospace and military sectors, while working at North American Aviation and the Boeing Company. He presently serves as a consultant to various governmental and industrial organizations. His short courses (which are presented in both the US and overseas) in such areas as Expert Systems, Goal Programming, and the AI/OR interface have been attended by more than 1800 individuals over the past decade alone. Dr. Ignizio is the author of six textbooks, numerous monographs, and approximately 200 technical papers — including more than 80 which have been published in a variety of international journals. He is a Fellow of IIE, the recipient of the First Hartford Prize, an NRC Research Fellowship, and is a member of the Fellowship of Operational Research (Britain). He is currently directing several research grants in the areas of AI and OR, including an effort for NSF in intelligent decision systems. He recently concluded research in recurrent neural networks for the SDI ("Star Wars") program.

Major General Mark R. Hamilton
Vice Director for Force Structure and Resources, Assessment Directorate
The Joint Staff

Major General Hamilton, USA, is the Vice Director for Force Structure and Resources, Assessment Directorate (J8), The Joint Staff, Washington, DC.

Major General Hamilton was born in Hackensack, NJ, and graduated from high school in St. Petersburg, FL. He earned a Bachelor of Arts degree from the US Military Academy, West Point, NY, in 1967 and a Master's Degree in English from Florida State University, Tallahassee, FL, in 1972,.

Major General Hamilton entered the Army in June 1967 with a commission from the US Military Academy. Prior to his current assignment, he served as Deputy Director for Joint Warfighting Capability and Assessment, the Joint Staff (J8), Washington, DC. His previous assignments include Deputy Director for Strategic Planning and Policy, HQ, United States Pacific Command, Camp HM Smith, Hawaii; Chief of Staff, Alaskan Command, Elmendorf Air Force Base, Alaska; Special Assistant to the Chief of Staff US Army with duty in Somalia and SHAPE Headquarters; Commander of the United States Military Group El Salvador; and Commander of the 6th Infantry Division Artillery, Fort Richardson, Alaska.

Major General Hamilton's awards and decorations include the Distinguished Service Medal, Defense Superior Service medal, the Legion of Merit with oak leaf cluster, the Bronze Star Medal, the Meritorious Service medal with silver oak leaf cluster, the Air Medal with silver oak leaf cluster, the Joint Service Identification Badge, the Army Staff Identification Badge, the Parachutist Badge, and the Ranger Tab. He was also awarded the Gold Medal for Distinguished Service by the President of El Salvador.

Dr. Paul Davis
Senior Scientist
RAND

Paul Davis is a senior scientist at RAND. His areas of current research include defense planning under uncertainty in the post-Cold War era, grand strategy, deterrence of third-world opponents, and advanced modeling and simulation. He is the editor of and author of several chapters in the major 1994 RAND book, "New Challenges in Defense Planning: Rethinking How Much is Enough." Dr. Davis recently completed a five-year position as RAND's Corporate Research Manager for Defense and Technology Planning. He is also on the faculty of the RAND Graduate School of Policy Studies, where he teaches classes in national security, technology and policy analysis, and systems analysis. Before joining RAND in 1981, Dr. Davis was a senior executive in the Office of the Secretary of Defense (Program Analysis and Evaluation), where he dealt with rapid deployment forces for Southwest Asia. He had previously worked there as a strategic nuclear analyst. From 1975 to 1977 he was on the staff of the Arms Control and Disarmament Agency, during which period he also served on the US SALT Delegation. Prior to that Dr. Davis was a senior scientist at the Institute for Defense Analyses, which he joined in 1971. Dr. Davis holds a BS from the University of Michigan and a PhD in Chemical Physics from MIT.

Appendix A3 – *Analysis in the Spotlight*
William D. O’Neil, Center for Naval Analyses

Analysis in the Spotlight

Responding Quickly to Analysis Needs for Major Decisionmaking

William D. O'Neil
Center for Naval Analyses

I must begin by thanking the Society for inviting me to speak to you about this timely and fascinating topic. It's been a stimulating exercise for me to compose and deliver this talk, and I hope that it will provide some measure of stimulation for you as well.

The topic, of course, is quick-response analysis: analysis conducted under pressures of time. I want to assure you that, in the full spirit of the conference, I began working on this talk only about ten days ago, and have had time to work on it only intermittently since, so it is in a way itself an example of the possibilities and limits of quick-response work. Like any good ops analyst, I promise to raise at least two new issues for every one I dispose of.

How you feel about quick response operations analysis tends, I observe, to depend a great deal on how you think about OR itself. Specifically, is OR to you a branch of mathematics, of science, or of engineering? If you believe that OR is about the *formal* content of models, and only about that—which is to say that you take a *mathematical* view of the field—then you may think that those who want models from your hand should have the good sense to plan ahead, and that in any event model development can not well be rushed. On the *scientific*

view of OR, as a method of inquiry and body of knowledge concerning operations, it may seem equally that importunate demands have little place in the order of things. I don't suggest that either the mathematical or scientific ops researcher is going to dismiss client needs for urgency, but he or she is likely to see them as an external intrusion and disruption rather than an integral aspect of the OR discipline.

I really would not claim to know what the *correct* or *proper* view of OR is, but you all will have guessed by now that my sympathies lie with the engineering camp. I was trained in mathematics and science and retain a deep interest in both, but of the many things I have done in my life, OR seems most like engineering. The distinguishing characteristic of the engineer is that his or her efforts are bent toward *creating* some *construction*—in this case toward creating operational procedures, structures, and systems—not accumulating knowledge. Of course a great many engineers spend much if not all of their time in accumulating knowledge, just as many ops researchers do, but with the ultimate object of creating something.

One of the things which makes sense to me about the engineering model for OR is that engineers generally

acknowledge (if not always joyously) the centrality of the customer or user or client—without whom there is no occasion for an construction and hence none for engineering effort (or engineers). Being of this cast of thought, the engineer is more ready perhaps than the scientist or mathematician—to whom the client is likely to seem more a patron and funding source and less an integral element in the endeavor—to accept client demands for urgency as legitimate and natural. Since no construction can be final or transcendental (at least as regards matters of utility and economy, if not aesthetics or sanctity) the engineer is compelled to view demands for “newer” and “better” as natural and even virtuous. And if a part of the construction’s utility lies in its availability by a date certain, then so be it. This is not to say that demands for urgency are without consequence or cost, in OR as in other forms of engineering.

(There are many more things important to know about OR which can be discerned by considering the engineering model, but that’s not what MORS so graciously invited me to speak about today. Some other time, perhaps.)

As we all know, OR can be and has been applied to a vast range of operations, even within the narrower context of military OR. It is in consequence something of a quicksilver sort of subject: mutable and hard to nail to the wall. The organization I have the honor to be associated with, CNA, is the oldest OR group in continuous operation in the U.S., and its history illustrates the point. CNA traces its origins to the ASW Operations Research Group, formed in April of 1942 to deal with a prototypical quick-response issue: defeating the Nazi

U-boat offensive then going on off our shores before it defeated us. It’s one of the epic stories of our profession and I’m sure you all know it. We continue in this line of business, though fortunately usually without staring calamity in the face *quite* so closely. But we do many other things as well, relating to different sorts of operations and situations. We arrived at our present form in large measure by accretion of organizations which were originally separate foundations and whose underlying unity was recognized only later.

Because CNA analysts go on field analytical assignments (with about 40 of our 225 analysts in the field today, including some in Bosnia) we probably tend more than most OR organizations to be called upon to contribute to urgent military operational needs. Indeed we not infrequently get calls which go something like: “I can’t tell you exactly what’s going on, but there are two carriers in Norfolk raising steam for sea and you should get two good strike analysts aboard before they sail.” Of course one of the fundamental rationales for having an organization like CNA in the first place is to provide a capability to respond quickly to urgent Navy and Marine Corps needs. In addition to sending our people to sea on ships bound for war and to tramp around places like Somalia, Haiti, and Bosnia, this gets CNA involved in many less warlike demands for short-fuse analysis.

Let me try to group these into some descriptive categories:

- ***Analytical contributions to planning near-term military operations.*** In particular, these often involve rapid assessment of

operational results and recommendations for immediate improvement. Sometimes they are conducted under the pressure of knowing that sailors and marines are about to risk their lives to achieve goals which are important for protecting the nation's interests; the deadline for making a contribution may be only days or even hours away. This is about as demanding and rewarding as OR gets.

- ***Rapid requirements and resource-allocation studies.*** Mostly these are things where the compressed time allocation could have been avoided in principle but not in practice. One common scenario is a new (new to the decision-maker, at least) problem or option which comes up at an awkward point in the PPBS cycle. The contractor who walks in with a tempting way of doing things better and cheaper two months before the POM has to be delivered, for instance, and the government has to take him up on it now or wait at least a year. So they call in the OR folks and say: "This looks like a totally new idea. Tell me whether it's really better and if so how much. You have a month."
- ***Analyses for Proposals.*** Not a CNA problem, but one I'm familiar with from earlier life in industry. There are actually a couple of sub-variants. One is the analysis required as part of or in direct support to a proposal for development and/or production of a hardware or software system, or provision of a comprehensive set of services. The RFP says they not only want a data link design but also the analysis which tells how good the design is likely to be. Often the RFP is quite specific about the models which are to be used and the cases to be run—not always what you might choose. These can be a real grind, but winning is nice. A bit more fun is the bid for an analysis contract where you include some analysis to show you know how, or the hardware, software, or services RFP where the analysis is not stereotyped. Here the challenge is likely to be communicating your results well to evaluators whom you won't get a chance to talk to.
- ***Design-support analysis.*** Operations analyses often play an important role in guiding the design of hardware, software, or services systems—though not as often as they should, probably. Design delays are very expensive and there are always pressures to make the process run faster. Design is typically done by a cyclic method of successive approximation and the pressure is always to make the cycles go faster and to cut the number of cycles required by improving the gain per cycle. Guess what this does to the operations analysis.
- ***Controversy-driven analysis.*** These are the bureaucratic and political analog to combat analyses, except that the "enemy" is someone who's trying to impose policies your client doesn't like or oppose policies he does—not kill his troops. Often each side in these controversies has its own set of OR people, producing the "dueling analyses" syndrome. These can bring all the joys of a root canal,

but at their best they offer an opportunity to exercise a positive effect on important issues of public policy.

There are some antinomies I see running through these categories which seem important to me:

- ***Normal analysis vs. radical analysis.*** At the one extreme, some analysis issues present with a clear structure. If you identify it as a linear programming problem, say, you may still face a lot of difficulties in solving it, but they will tend to be more of a practical than a conceptual nature. But some issues are so vaguely defined or so novel as to make formulating them in the first place to be the principal problem.
- ***Private analysis vs. public analysis.*** When the client has full power to do whatever may be done on the basis of the analysis results then the analyst has only to convince him of the validity of the analysis to have an impact. A happy situation, and the one in which OR first flourished. But often the client must bid for resources or influence, with your analysis as coin, impelling you into the lists, armed cap-à-pie or naked to his enemies, as your case may be. Those who have led a life of public analysis can find private analysis bewildering, and conversely.

I term these antinomies because to many it will seem that one alternative or another is the *right* and *proper* one. As my terminology suggests, I accept that normal and radical analysis, private and public, each have their place and each must be honored in its own territory. But

there are tensions between them, and these will figure largely in my discussion of the problems and challenges of quick-response analysis.

I see these problems and challenges as falling mainly into seven categories:

- Planning in a fluid environment.
- MOEs and scope of the analysis.
- Structuring and organizing the analysis.
- Choices of models and tools.
- Communicating the real meaning of analytical results.
- Professional identity and standards vs. commitment to clients.
- The analyst's broader responsibilities.

Let me address each in its turn, starting with...

Planning in a Fluid Environment. This is often a crucial practical problem, and dealing with it effectively is essential to the success of quick response work. Some people seem naturally better at this than others, but a lot of it is skill which can be systematically developed. First of all, just as our military clients discovered long ago, it pays to think about and plan for contingencies in advance. An ops analyst who's really close to his or her client organization should be aware of its problems and needs to an extent which will allow for preparation against a great many of the contingencies it's likely to face. (One exercise I recommend: if your client encounters a problem you didn't

foresee, ask yourself why—and don't let yourself off the hook too easily. If I'm such a great analyst, why didn't I see this coming?) There are few pleasures in this business that are richer, in my estimation, than having the client run in with his hair on fire and being able to tell him: "I know all about it—that's why I got you to let me do that study last year. I've got the answer right here." Of course it rarely works out quite that neatly in practice, but even partial foresight can be highly valuable.

Try as we may, though, there will be contingencies we haven't foreseen, or haven't had the opportunity to prepare for. But, again to take a page from our clients' book, thought and frequent exercise in crisis response can do a lot for preparedness. If you have to dispatch an analyst halfway around the world, to some Godforsaken and pestilential spot with no facilities, as CNA frequently must, it pays to have rehearsed the process even if you had no advance insight into the actual destination.

Perhaps this is a problem your organization doesn't share. But almost everyone can profit from some attention to keeping research materials and tools in good order. What about that model you haven't used in a year or so? Might you want to use it again? If so, it could be a good idea to spend some rainy afternoon exercising it, to make sure you still can. What about that great report Helen did ten years ago, before she retired? Could you find it in a hurry if you needed to? CNA has a vast repository of research materials—our products and others—with an automated bibliographic system and professional librarians to tend it. This is all a big expense which weighs heavily on our

overhead, but it's invaluable in responding quickly. Waiting until the alarm rings and improvising is not likely to yield good results.

Of course, ops analysts who have examined military operations in contingencies will be well aware of some common pitfalls. One classic is the organization which has become so well practiced in executing its contingency plans that it does so before recognizing that they aren't relevant to the contingency actually at hand. More commonly, one finds that a unit is prepared intellectually and materially for a contingency but not socially or emotionally. If a key leader goes into a blue funk in response to the shock of the unanticipated, disaster is very likely.

MOEs and Scope of the Analysis.

There's an entire session devoted to this later, I know, but perhaps a few general comments belong here. It often works out for the better, we all know, to use what may seem like fairly abstract and recondite MOEs, because they lend themselves better to the analysis models and tools which are available. But this sort of approach tends to work better in *private* analysis than in public.

In what I have called *public* analyses we face the problem of the external audience for our analyses—usually intelligent and sometimes quite knowledgeable about many aspects of the operations under study, but often both opinionated and analytically naïve, and frequently disposed to skepticism if not outright hostility. In such cases, I submit, it is often better to use a broad range of MOEs representing a wide variety of ways of looking at the processes we study. If the MOE set is

well chosen, it can reduce the risk that we will be found to have overlooked some important if subtle aspect of the problem. (And the use of multiple appealing MOEs can be useful in dealing with critics who want to reduce a complex issue to a univariate optimization problem.) This can also be a useful strategy in investigating complex novel issues or situations, in which we have limited experience to guide the choice of MOEs. Of course, multiple MOEs can also complicate the analysis a good deal.

Structuring and Organizing the

Analysis. Of course this is crucial in any analysis, but quick-response situations narrow the margin for error. I don't need to tell anyone here, I'm sure, that a failing in this regard is to plan for an analysis which will take six months at very best, when only four are available, and tell yourself that, "we're going to do it better this time." There are few things sillier than an ops analysis organization which can't analyze its own operations well enough to predict how long *normal* analyses will take and what is required in order to do them faster, but we all know the story about the shoemaker's children.

A more subtle problem is the *radical* analysis issue which has enough novel elements to be beyond one's ability to lay accurate plans. This is another place, I believe, where it's useful to look at engineering practice. Prudent design engineers like to take on one risk at a time—to depart from established and tested practice in only one major subsystem, while making no more than incremental improvements in the others, for example. Sometimes, however, a more radical solution is needed, or shows enough promise to justify added

risk. One of the strategies engineers adopt in such situations is a sort of method of successive approximation, developing a series of models of increasing complexity and fidelity to improve their state of knowledge and reduce risks. A good design engineer will be able to come up with a great many different ways to model the system he is designing, ranging from mathematical models which can literally be written on the back of an envelope and evaluated with a hand calculator to highly-realistic and representative simulations costing perhaps hundreds of millions of dollars. He may require years and billions of dollars to fully resolve the risks and deliver a polished result, but if all he has is six months he may very well be able to significantly narrow the uncertainties. I submit that much the same thing is often possible in operations analyses, even radical ones.

How, you may ask, does this relate to time-urgent analysis under conditions of uncertainty? The point is this: if you have, say, three months and commit yourself to an approach which you believe will take 80 days then you may be left with nothing at the deadline if you encounter unforeseen difficulties. But suppose instead that you plan to do *five* complete analyses—each a more complex, comprehensive, and faithful representation than the last—to mature on days 16, 32, ... 80. Experience in the course of the earlier, approximate analyses may perhaps help you steer clear of the shoals which would otherwise ground the fifth analysis. But even if this doesn't save the ultimate analysis from wreck, you will still have the penultimate analysis, or the one before that, to fall back on. Obviously, in

a world of finite resources there must be some tradeoff: if we do five analyses then none will be as elaborate and comprehensive as a single one might be. But the gain should be weighed against the risks consciously and explicitly.

Choices of Models and Tools. This is another area where there tends to be an important difference between private and public analysis. Often, particularly in normal analysis, you will know at once that there is one logical standard analysis tool, a computer code which is universally used by ops researchers in your community for such purposes. If it's private analysis and you know and trust the tool—and if your client doesn't entertain any insurmountable prejudice against it—then this is a smart way to go. Among other things, use of familiar tools is likely to reduce the variance in your estimates of how long the analysis will take.

But if the analysis is public, and particularly if it's likely to be controversial, the rules may be different. Critics may regard your favorite tool as intellectual garbage, and in any event are almost sure to take a very searching look at it. Even a fully accredited tool (if there is such a thing) may not escape savage criticism, depending on the authority and basis for the accreditation. Obviously, you can't avoid using tools of some sort, but you should consider whether you are likely to be challenged concerning their use, and if so how you will respond. This can be another benefit of the successive approximation approach, since if the results from the simple and transparent early-approximation models are consistent with the more complex and less-easily understood later ones then it

tends to lend an added measure of credibility.

In private analysis, particularly in normal private analysis, your experience may tell you that there are only a relatively narrow range of variables which really matter, and give you insight into approximately the right values, so that you can sharply limit the number of cases to be analyzed. Often this can make it possible to achieve a lot of depth and precision in the analysis even within a limited time. But in public analysis, you again encounter the problem of skepticism, and perhaps hostility, from some audiences. In such cases it is prudent to run not only those cases which you know make sense but also those which some critic may suppose (even if wrongly) could be attractive. And of course in radical analysis there is also usually need to examine a wider range of cases to assure that nothing has been overlooked. Again, of course, there is a tradeoff between the number of cases to be examined and the depth in which they can be treated.

Communicating the Real Meaning of Analytical Results. Again, this is to be the subject of a separate session, which will no doubt cover the issue better than I could hope to. Let me simply remark that the most common problem I see, which tends to be exacerbated by pressures of time, is failure to distinguish adequately between the model and its object, and to explore whether and to what extent the relationship between them is strong enough and broad enough to sustain the weight being placed upon it.

Professional Identity and Standards vs. Commitment to Clients. I expect

that most sociologists, looking at the OR field, would conclude that its identity and status as a learned profession is at best only moderately securely established. This tends, reasonably enough, to make us all a bit more sensitive about professionalism and standards. Sometimes ops researchers can as a result come across as stiff-necked to clients who want it by a certain time (or done in a certain way). Of course there are usually better and worse ways to express one's views on such matters, and to my taste it doesn't seem too much of a compromise of professional integrity to express one's standards in cool and soft tones.

At best, however, some conflict between the analyst's professional standards and the client's demands is frequently not entirely avoidable, and such conflicts are more common and harder to work out when the analysis is conducted under pressure. Conflicts are especially likely when the analysis is public, of course, but even private analysis clients can be quite difficult when it comes to frank and open examination of cherished assumptions and traditional practices.

Again I think it can be instructive to examine the practices of the engineering profession, which over the past decade or so has been discovering that lowering professional *barriers* can actually be helpful to maintaining professional *standards*. In particular, fostering more frequent and intimate communication and closer and more collaborative relations between the various engineering disciplines and the user communities has been found to pay major dividends. (Of course this can be very difficult when the contracting

officer seems maniacally determined that what is good for an analysis contractor must be bad for the government client, and vice versa. The recent efforts at procurement reform are supposed to alleviate this in dealings with the government, and most clients in industry got the word some years ago.) Much of the secret is to establish analyst-client structures which convey the message that this is a professional collaboration, based in mutual respect. Trendy approaches such as *integrated product teams* can be useful if not pressed to the point where everyone becomes jaded and cynical about them.

Of course close analyst-client relationships do little to soothe the client's sworn enemies in a public analysis. But often there are important audience groups which are skeptical but not cynical or hostile, who can usefully be integrated to one degree or another into the collaboration as a means both of enriching and extending the analysis and co-opting potential critics. (That is, unless one enters into such things with a genuine willingness to hear what the skeptics have to say and take some action on it, efforts at co-optation are not likely to go well.)

The Analyst's Broader

Responsibilities. While I've emphasized the parallels between OR and engineering, in some ways we're not unlike lawyers. And no, I'm not trying to suggest that a hundred ops analysts at the bottom of the pool is only a good start. But we have something of that kind of relationship to our clients in many cases—especially in public analysis cases. Of course a lawyer, at least a lawyer admitted before the bar, has a legal obligation to the court and the

justice system which transcends and limits his relationship with his client. Now this doesn't keep attorneys as being widely perceived as unprincipled avaricious scoundrels who would sell their sisters into chattel slavery for a buck, or just for the hell of it. Yet ops analysts lack even the threadbare cover of being "officers of the court."

Are we then simply to be hired advocates? Many of us don't feel comfortable with that notion, I think. One of the main attractions of professional status for many ops analysts, I believe, is the reinforcement and sanction that it gives to their innate belief that the truth is important. I also observe that one of the attractions of military OR to many of us is a sense that military clients on the whole are dedicated to an ideal of public service which we find very appealing. I recognize that I don't speak for everyone in this and that some, particularly in private firms, would take the view that they offer a professional service which they make impartially available to any qualified client, without judging the virtue of his purposes, much as many lawyers do. But those ops analysts whose views are closer to this pole generally share with the others a genuine devotion to professional standards of truth just as, in reality, most lawyers do.

I retain sufficient idealism to find both motivations appealing: the devotion to professional standards of truth as well as to the ideal of public service. But neither is altogether without its pitfalls as a guide to how to conduct our affairs. These problems are not unique to cases of quick-response analysis, of course, but they are likely to be met in starkest form here, most particularly when the

analysis is of a public nature. I don't have a lot of answers, but let me (in the best analytical tradition) propose some questions:

- Is the truth we are defending one of form or substance? This is one which often contributes to the legal profession's dubious repute, and threatens sometimes to perform the same service for OR. Fundamentally it can be viewed as a question of distinguishing the *model* from the *object*.
- Is this a case in which it is realistic to believe that we *could* ascertain and grasp the whole of the relevant objective truth, or will truth in fact better be approached by a dialectical process (or what we may, with some violence to etymology, call a many-sided *polylectical* process) in which framing and making the best arguments for each point of view plays an invaluable role?
- Is our client actually adhering to the standards for which we admire him? If not, need we resign his service, or are there ways to recall him to his duty?
- Are we straining at gnats? Or is this a matter of genuine—even if perhaps subtle—significance?
- What are our real standards? Why do we hold to them? Is this an issue of standards, or of testosterone?

Draft, 24 September 1996

Appendix A4 – *Intelligent Decision Systems – A Brief Overview*
Dr. James P. Ignizio, University of Virginia

INTELLIGENT DECISION SYSTEMS: A *Brief* Overview

Dr. James P. Ignizio

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MORS Meeting

1 October 1996

EVERYTHING OLD IS NEW AGAIN

- As an amateur historian of military operational research and decision making, I am struck by the fact that:
 - » None of the military sector problems have really changed; only the technology (e.g. Waddington)
 - » Few of the "solution" methods have changed — just means of implementation — or names (e.g., heuristic programming/expect system/genetic algorithms ... or experimentation/simulation)
 - » Yet we never seem to appreciate this; nor do much about it

Here's the answer ... what was the question?

- You are asked to develop a model to evaluate weapons, forces, policies, etc. for various combat scenarios
- You "start" by choosing from among approaches in parallel/distributed processing
- You discover that, by using, say, hyper-wavelets, you are able to process larger and more detailed simulation models
- QUESTION: What good does it do to process larger, more detailed simulation models if simulation might not be the most appropriate approach?
- QUESTION: Will faster processing and more detailed models provide improved insight and understanding

10/25/96 (1230) (3)

AN OBSERVATION

- "Problem solving" should be more than just grinding out *more* numbers, *faster*, and more "exotically"
- For example:
 - » Current emphasis on "modeling of human behavior" too often results in the replication of poor to mediocre human performance — thru "AI"
 - » Current emphasis on distributed computing may result in faster brute force, trial and error
- Isn't it time to look at things a bit "differently?"

10/25/96 (1230) (4)

PRESENTATION OVERVIEW

- Presented per requests from attendees of my 5-day short courses on Intelligent Decision Systems
- Covers a few basic concepts in problem identification and understanding
(Represents but roughly 2.5 percent of the material in the actual course)

10/28/98 (1230) (5)

PROBLEM TYPES

- We are taught that problems are classed as:
 - » linear, nonlinear or integer problems
 - » simulation problems; distributed simulation problems
 - » assignment, transportation, and distribution problems
 - » queuing problems
 - » close-air support problems
 - » force-mix problems
 - » logistics problems
 - » resource allocation problems
 - » AI problems; OR problems; CS problems, EE problems, ... etc., etc.
- This contributed little to our solution, understanding or appreciation of real-world problems

10/28/98 (1230) (6)

COGNITIVE PSYCHOLOGY

- There have been significant advances in cognitive psychology, as well as cognitive psychology in conjunction with “AL” models and experimentation
- Why not make use of this knowledge — even if it isn’t “traditional” OR?

10/25/96 (1230) (7)

PROBLEM TYPES: According to Ignizio

- Rather than having a massive list of problem types, as identified mainly by either a tool for solution or specific application, there are but THREE types of problems:
 - » problems of association
 - » problems of construction
 - » problems we do not yet understand

10/25/96 (1230) (8)

PROBLEMS OF ASSOCIATION

- Such problems involve the *association* of certain attribute-values to a specific object, or conclusion
 - » Prediction, forecasting
 - » Classification, pattern recognition, signal processing, pattern classification, decision making
- Note: that these problems are typed according to the basic operation(s), or “primitives”, required for solution, *rather than some particular application or algorithm!*

10/28/98 (1230) (9)

EXAMPLES

- Prediction:
 - » weather
 - » stock price
 - » force attrition
 - » probability of kill
- Classification:
 - » friend or foe (yes, no, unknown)
 - » candidate for promotion (good, fair, poor)
 - » investment potential (good, fair, poor)
 - » credit score (good, fair, poor)

10/28/98 (1230) (10)

PROBLEMS OF CONSTRUCTION

- Construction problems require either:
 - » the construction of a MODEL (that may be used for deduction, abduction, or induction) by means of a series of associations, or
 - » the construction of a SOLUTION from an existing model by means of a series of associations
- Most people focus on the latter use (i.e., solutions), yet the former is — by far — the most important!

10/28/98 (1230) (11)

EXAMPLES

- Develop a linear regression *model*
- Develop a linear programming *model*
- Develop a network flow *model*
- Develop a simulation *model*
- Develop the *program* for an LP model
- Develop the *program* for a GA model
- Develop the *program* for a scheduling model
- Develop a *policy* from a simulation model

Have you ever used LP to build LP models?

If not, WHY not?

10/28/98 (1230) (12)

The 3rd problem type: those we simply don't understand

- Why does A "love" B?
- How do babies learn to speak?
- How did Hillary make all that money in commodities market?

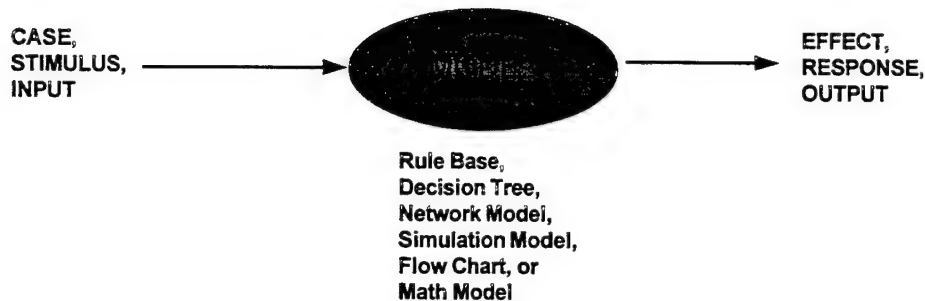
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For every problem, at least one goal

- Problem goals are either:
 - » Deduction
 - » Abduction
 - » Induction
 - » or some combination of above
- What are *your* goals? Why do you build an LP model? A regression model? A simulation model? Use regression? Use LP? Use simulation
- Why aren't these questions ever asked?

10/28/98 (1230) (14)

DECISION SYSTEM SCHEMATIC



10/28/98 (1230) (15)

DEDUCTION

- Given both the cause *and* the model, *determine* the effect (e.g. given the input and the rules, determine the output)
- Example: "prediction"
 - » **Known:** the model — the prediction function
 - » **Known:** the input — the values of the decision variables
 - » **Desired:** the output — (the prediction or estimate)
- Example: "classification"
 - » **Known:** the model — rules of engagement
 - » **Known:** the input — the target's attributes
 - » **Desired:** the decision — on engagement (fire or not)

10/28/98 (1230) (16)

OBSERVATION

- In the case of both the problem of prediction and the problem of classification, as described, the resultant decision is “data driven”
- The process flows from left to right — or forward
- Moreover, previous examples represent the implementation of prediction and classification

10/28/98 (1230) (17)

ABDUCTION

- Given both the effect and model, determine the cause (e.g. Given the output and rules, determine the input)
- Example: “prediction”
 - » **Known:** the model — the prediction function
 - » **Known:** the output — the result (target missed)
 - » **Desired:** the input — (the cause)
- Example: “classification”
 - » **Known:** the model — rules for weapons mix
 - » **Known:** the output — desired level of effectiveness
 - » **Desired:** the input — (the cause; e.g., the mix that will lead to the desired level of effectiveness)

10/28/98 (1230) (18)

OBSERVATIONS

- Note: that while both problems are of the same type (association) as before, the decision process is now “goal driven” (e.g., Given a conclusion, or some hypothesized result, determine the cause)
- That is, the process flows from right to left – or backward
- Here, rather than implementing the prediction or classification process, we seek to understand the causes of a particular prediction/classification — or seek the optimal policy that would lead to that result.

10/28/98 (1230) (18)

INDUCTION

- Given both the effect and the cause, determine the model (e.g. given the output and input, determine the math model — or the system that produces such an output)
- Example: “prediction”
 - » **Known:** the input — the cause, or data
 - » **Known:** the output — the result
 - » **Desired:** the model — the prediction *function*
- Example: “classification”
 - » **Known:** the input — the cause, or facts
 - » **Known:** the output — the weapon system’s fault modes
 - » **Desired:** the model — rules for diagnosis

10/28/98 (1230) (20)

OBSERVATION

- In the case of induction, we do not “move forward or backward”. Instead we seek to determine the rules/model that relates the cause with the effect
- Despite facing precisely the same problem types (e.g. problems of association), the solution concept is dependent upon just which part of the process is required to be identified:
 - » The effect: deduction
 - » The cause: abduction
 - » The model: induction

10/28/98 (1230) (21)

INDUCTION = SYNTHESIS = DESIGN

- Induction is that goal of seeking to determine the “model” to explain a given effect for a given cause
- This is precisely what we seek when we design (synthesize) a system; e.g., Given the “specs” (design requirements = expected inputs & desired outputs), we seek to design a system that will respond accordingly

10/28/98 (1230) (22)

OBSERVATIONS

- Only 2 types of problems of interest in scientific decision making: those involving association, those involving construction, or those involving a combination of BOTH
- Typically but just 1 of 3 types of questions to be answered: (i) what is the effect?, OR (ii) what is the cause?, OR (iii) what is the mechanism that provides a particular effect for a given cause
- Associated with each of these question are but 3 solution goals: *deduction*, *abduction*, and *induction*

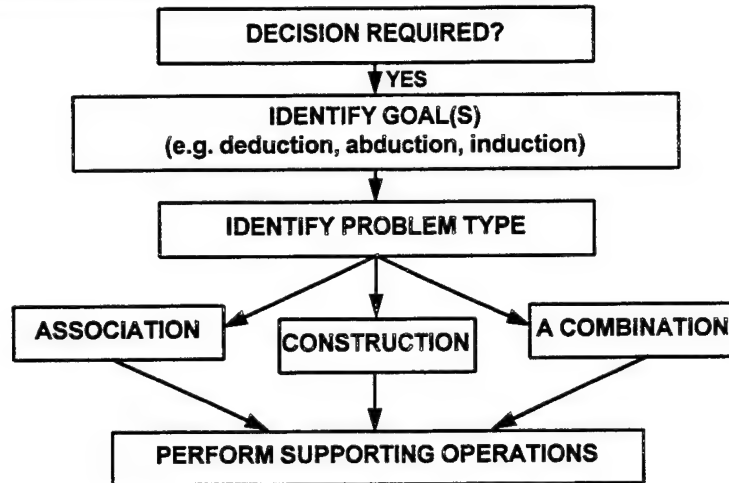
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IMPLICATION

- Decision making/problem solving is conceptually a very simple process — and one that remains constant regardless of the domain, supporting tools, or jargon
- This observation is obscured by the proliferation of courses that each address a single supporting tool (e.g. Simulation, Distributed Simulation, C++, LP, GAs, SA, NLP, ILP, ETC.) without ever once indicating just where this tool fits in the scheme of things

10/26/98 (1230) (24)

A possible decision process schematic



10/28/98 (1230) (25)

SOLUTION METHODS: The Three Philosophies

- The three philosophies of solving problems:
 - » Mimic Human Decision Making
 - » Mimic Mother Nature
 - » Employ Artificial Means

10/28/98 (1230) (26)

MIMIC HUMAN DECISION MAKING

- Expert Systems
- Case-Based Reasoning
- Use of analogies (can experiences fishing teach you how to conduct military exercises?)
- Heuristic rules

10/28/96 (1230) (27)

MIMIC MOTHER NATURE

- Neural Networks
- Polynomial Networks
- Genetic Algorithms
- Evolutionary Programming

10/28/96 (1230) (28)

ARTIFICIAL MEANS

- Simulation (or any other form of computerized brute force, limited search)
- Simplex, math programming
- Calculus
- Interior point search
- Numerical search
- Vector analysis
- Any other approach *not* based upon mimicking human decision making or Mother Nature

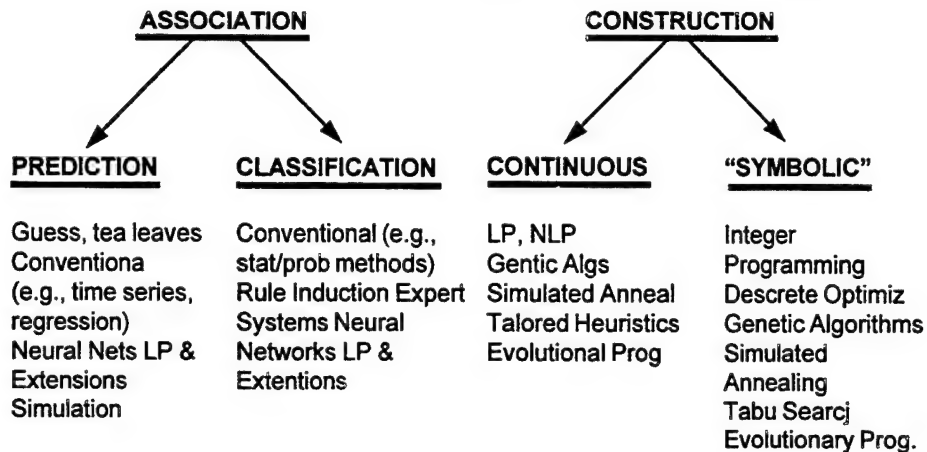
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IMPLICATIONS

- Under this philosophy, problem solving is focused toward gaining insight and understanding of the system under consideration
- Under this philosophy, we should spend more time identifying the problem type and its goals, and matching it to the most appropriate means of solution/analysis — the most vital part of any analysis

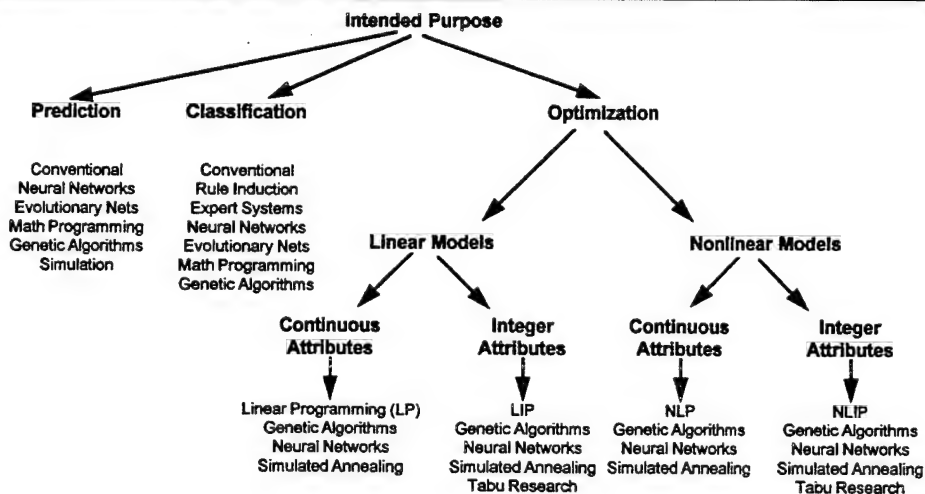
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PROBLEM TYPES & ASSOCIATED TOOLS



10/29/96 (1230) (31)

DECISION TREE: Tools & Purpose



10/29/96 (1230) (32)

SOME EXAMPLES

- SAM-D/Patriot Air Defense System
- Army Battalion Training Model
- SDI ("Star Wars") Task Scheduler
- Rapid Deployment Force Mix
- Light Area Defense Engagement Model
- Off-Shore Drilling Simulation

10/28/96 (1230) (33)

SAM-D/Patriot Air Defense System

- Description: Deploy missile and radars so as to minimize enemy "leakage"
- Observation: Must INDUCE models that may be used to CONSTRUCT a deployment scheme.
- Induced heuristic rule set/expert system associated with siting of air defense systems; induced evolutionary programming model for refinement of the heuristic-derived deployment.

10/28/96 (1230) (34)

Army Battalion Training Model

- Description: Determine frequency and types of training exercises needed to achieve a desired level of combat readiness
- Observation: Need to INDUCE two models; one to ASSOCIATE readiness to exercises, other to CONSTRUCT a schedule
- Induced Classification/LGP model to determine number & types of exercises; induced Construction/permutation Search model to determine actual schedule

10/25/96 (1230) (35)

OBSERVATIONS

- Had we simply modeled human behavior in these problems we would have replicated mediocre performance --- and had we used simulation we would have been using a far less effective approach
- In the SAM-D/Patriot case, no human expert came within 70% of our results
- In the battalion training model, we reduced the time to schedule the exercises by 50% or more over that of "the best" human experts

10/25/96 (1230) (36)

SUMMARY

- Our goal *should* be to gain insight and understanding of the problem under consideration
- But the typical approach is to pick the most current fad, and then wonder why we wasted so much time on so many false starts
- We don't really need "new" methods; we need a new philosophy

Appendix A5 – *Adaptiveness in National Defense*
Dr. Paul Davis, RAND

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Issue Paper

RAND

National Defense Research Institute

AUGUST 1996

Adaptiveness in National Defense: The Basis of a New Framework

Paul K. Davis, David Gompert, Richard Kugler

INTRODUCTION

After the November 1996 election, regardless of who is elected, there will be a review of national defense strategy. Much of the current debate revolves around "How many and which major regional contingencies (MRCs) should the United States be prepared to fight and how many forces are needed to get the job done?" This is the wrong question. The right one is larger: "How can DoD best build a defense posture for pursuing U.S. strategic objectives in this era of flux and opportunity?"

The answer, we believe, involves planning and building a U.S. force posture to meet three tests. The "posture," which involves not just the forces but also patterns of deployment, readiness, and operations, should be able to (1) *prevail* in highly diverse war-fighting contingencies, large and small, sudden and not so sudden (slowly developing); (2) *shape* the future international security environment; and (3) *adapt* to changes in strategic conditions. This paper describes a framework for defense planning that emphasizes and unifies these tests. It provides a new prism through which to view and assess alternative defense postures. We intend our proposals to be practical to senior leadership; yet, they are radical in urging basic changes in the way the Department of Defense (DoD) does business.

The central precepts of our approach are as follows:

- DoD's toughest challenge is to confront geopolitical, technological, and budgetary uncertainty that is unprecedented in the post-World War II era. The challenge requires setting enduring strategic goals,

which include but go beyond war-fighting goals, and assuring that the evolving defense posture always points toward those goals.

- A key element here is that the very nature of warfare is changing, in ways not yet fully understood. This means that DoD has the difficult task of deciding how and at what pace to *transform and recapitalize* U.S. forces to provide contingency capabilities for a new era of warfare and adversaries who learned from Desert Storm.
- Although preparing for possible contingencies is DoD's core concern, the United States—because of its international and technological strength—can also *shape* the future environment to some degree, not just react to it. To do so means integrating DoD force planning with U.S. foreign policy more broadly than comes naturally within the threat-based planning framework. As part of this, we see the need to strengthen our overseas presence and coalitions because the perimeter of U.S. interests is growing, not shrinking.
- Finally, the defense posture must be not only superior but strategically adaptive because the international and military environment will continue to change, as may national priorities.

Taken together, these precepts of *planning for adaptiveness* suggest a *portfolio management* approach to defense planning, a practical and realistic approach that would facilitate regularly reviewing and adjusting emphasis within the program to support the multiple goals related

to contingency capability, environment-shaping, and strategic adaptiveness.

In the following pages we review traditional “threat-based planning” and its shortcomings. We then describe our alternative framework and identify broad force-posture options that should be assessed within it. Finally, we summarize preliminary analytical results.

THREAT-BASED PLANNING AND ITS SHORTCOMINGS

Background

Since the early 1960s the Department of Defense has assessed the defense program in terms of how many wars could be fought concurrently with the envisioned forces. It has had defense programs geared to 2-1/2 wars (1960s), 1-1/2 wars (1970s), multifront global war with the Soviet Union (1980s), and, lately, two major regional contingencies.

Under each of these, the DoD has used “point threat scenarios” as test cases for Service programs. Figure 1 illustrates what such a scenario might look like today, using notional numbers.¹ It assumes that Iraq invades Kuwait, after which North Korea invades South Korea (the reverse might be assumed instead). Not only are the adversaries specified, but so also are many scenario details—even the chronology. This scenario may be *one* good test case, but it is clearly inadequate unless it is a bounding case or truly representative of all likely contingencies. Today’s MRC scenarios are neither. They suppress uncertainty rather than force us to face up to it, and they do not satisfactorily measure the adequacy of our force posture.

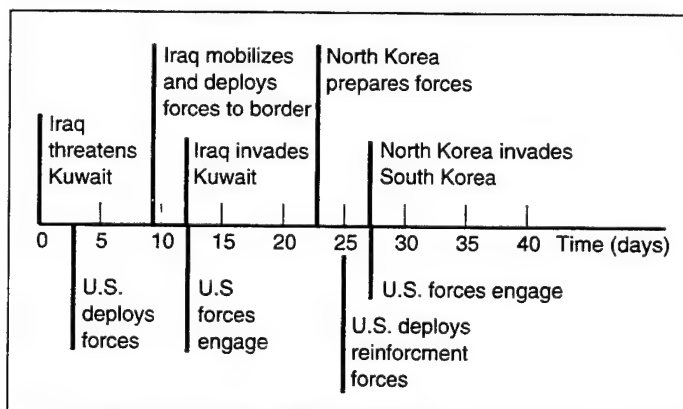


Figure 1—Schematic of a Threat-Based Planning Scenario

¹The Department has sometimes provided additional scenarios reflecting, e.g., lesser regional contingencies. It has always exhorted the Services to consider a range of cases in developing programs. In practice, however, attention has centered on a “big scenario” analogous to Figure 1. This is of concern to the DoD, which is considering changes.

To be sure, Secretaries of Defense have always recognized that U.S. forces will be used in unanticipated ways. They have seen the scenarios as mere *illustrative* test cases, and as valuable elements of declaratory policy and deterrence. During the Cold War, they could be confident that building forces for any reasonable point scenario involving the massive and multifaceted Soviet threat would generate forces with considerable inherent flexibility—with nuclear weapons to provide insurance.

In 1993, Secretary of Defense Les Aspin considered alternatives, including suggestions from General Colin Powell to focus more on generic war-fighting needs. But Aspin chose to stick with the threat-based approach because he still judged it necessary in convincing Congress to support an adequate defense program—and because Iraq and North Korea were convenient and credible villains, whom we have no hesitation to label as such. Aspin expected inside-the-Pentagon planning to go well beyond the point scenarios. His *Bottom-Up Review* made clear the limited purposes intended for the test cases.

In practice, however, DoD remains “hooked” on the simple formula of optimizing for the official scenarios (e.g., in building forces that get to the region just in time to prevail in those scenarios). The threat-based approach is seductive. It provides a single, simple yardstick against which to measure the adequacy of U.S. forces. It is therefore easy to explain and thus to gain public support for defense, especially when the threats are real and vivid. It also allows the Department to coordinate planning across Services, demanding that all of them build forces to satisfy needs of the planning cases.² In sum, the threat-based approach makes it easier to get everyone, from the Services to the Congress, to march to the same drummer—even if the drumbeat is rather arbitrary or too limiting.

Problems of Framework

Whatever its attractions, the point-scenario threat-based approach is wrong for our era. This is not a mere defect in the esoterica of defense planning. The problems are real and serious:

- *Inappropriate Peacetime Posture.* U.S. forces are being run ragged in operations having essentially nothing to do with the planning scenarios that have determined the “posture” (i.e., not only the active and reserve force structures, but also deployments, readiness levels, and priorities). As a result, we have witnessed serious operational stresses, confusion in the ranks about mission, hasty improvisation, and occasional sub-par performance—despite having the best

²This said, the Navy and Marines have always sized forces for presence and crisis-response, not just MRCs.

military technology and personnel \$260 billion per year can buy.

- *Achilles' Heels.* Even if war actually occurred in the Persian Gulf, Korea, or both, our adversaries would likely try to exploit Achilles' heels that do not even show up in the standard planning scenarios. Potential adversaries already know better than to confront our forces as in Desert Storm. We are more vulnerable to military failure than is generally realized.
- *Failure to Assess Adaptivity.* Too often, DoD studies of force and weapon options focus on optimizing for the point planning scenarios and a baseline of numerous detailed assumptions. This is quite pernicious, since the results are then strongly biased by the semi-arbitrary assumptions, which are often the result of compromise in committee.
- *Political Fragility.* The defense budget would be quite vulnerable politically if the Iraqi or, more likely, the North Korean threat were suddenly to vanish. In such a case, would we immediately cash in half our force posture as many would surely suggest? Certainly not, for good reasons. But then why not make those reasons the basis for our defense program in the first place?
- *Questionable Suitability for the Future Strategic Environment.* Will the forces we are developing, measured against today's two threat scenarios, be able to deal effectively with new adversaries, allies, regional alignments, technologies, and missions? Quite possibly not, and changing the posture quickly will be impossible without years of preparation.

The danger is just as great that we will fail to exploit U.S. advantages. Designing forces on the basis of fixed current threats and current ways of fighting is exactly the wrong bias as we stand on the doorstep of a revolution in military technology.

PLANNING UNDER UNCERTAINTY

How One Plans Under Great Uncertainty

Whether in business, sports, or war, the school solution for dealing with uncertainty is to embrace *planning for adaptiveness*. This is intuitive to modern American CEOs, football coaches, and field lieutenants; it is DoD that is peculiar in having focused on point cases. This said, we still have to know what our military forces might need to do. A call for unbounded adaptiveness would amount to calling for a blank check. This drives us back to where all good planning should begin, with objectives.

National Objectives for Planning Future Forces

Drawing on recent statements by Secretary William Perry and General John Shalikashvili, we can encapsulate

key ideas in the useful mantra "promote, prevent, defeat," which suggests three national security objectives: creating conditions to avoid conflict, deterring and otherwise preventing aggression when it is threatened, and defeating it when it occurs. For thinking more specifically about defense programs and postures, we suggest three related and supportive *investment goals* to ensure that, despite current uncertainties, future postures will permit us to promote, prevent, and defeat: The goals are

- *a force posture robustly sufficient at all times for a wide range of contingencies ("operational adaptiveness")*
- *a force posture that can influence favorably how the world evolves—to help "shape the environment," as an element of U.S. foreign policy*
- *the capacity to change our military posture over time as trends and events dictate ("strategic adaptiveness").*

It follows that we should be testing alternative force-posture plans against these separate investment objectives, as depicted in Figure 2 and discussed below.

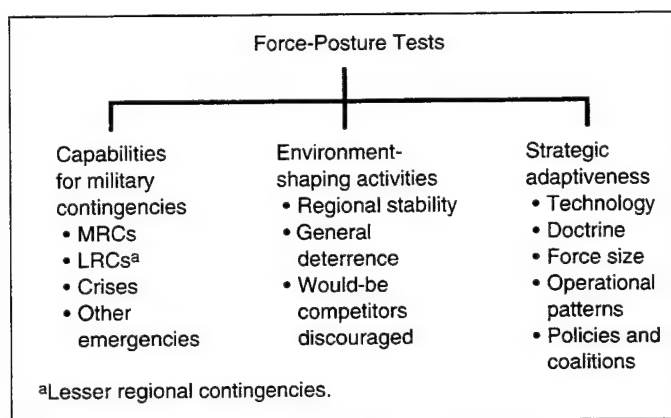


Figure 2—Testing Force Postures

Operational Adaptiveness: Capabilities for Diverse Contingencies

In evaluating the sufficiency of forces for military contingencies, the key is to move beyond one or two point scenarios toward a much broader exploration. Focusing here on the war-fighting aspect, this involves two distinct steps (Figure 3). The first is to consider a much longer list of plausible political-military scenarios (e.g., those in Figure 4), including some that are politically sensitive—both because they include nations such as Russia or China, which are not and we hope will not become adversaries, and because they consider U.S. intervention in hypothetical conflicts where our interests are controversial or our capabilities would be limited.³

³From time to time over the years there have been efforts by DoD to include sensitive scenarios or to include purely generic scenarios raising similar challenges. Unfortunately, these laudable efforts have sometimes been criticized with accusations that DoD was trying to create threats.

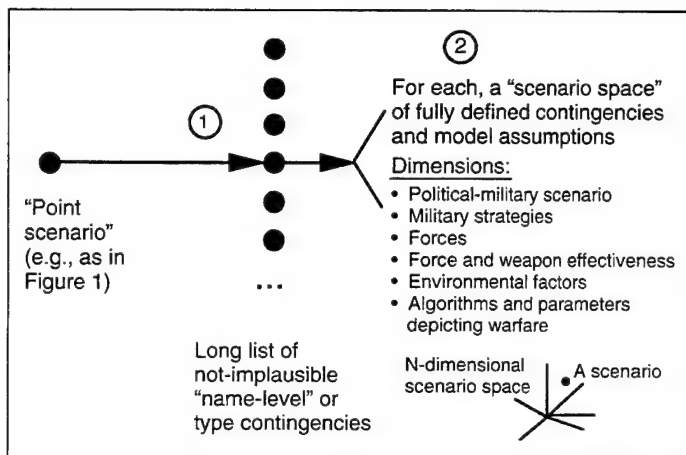


Figure 3—Moving from Point Assumptions to Scenario-Space Testing

Iraq vs. Kuwait and Saudi Arabia
 Iran closes Strait of Hormuz
 Iran and Iraq vs. Kuwait and Saudi Arabia
 Russia vs. Ukraine
 Russia vs. Poland
 Russia vs. the Baltic states
 North Korea vs. South Korea
 North Korea and China vs. South Korea
 China vs. unified Korea
 China vs. Taiwan
 China vs. Vietnam
 A “next Bosnia” in the Balkans
 China seeks to control East Asian ocean regions
 Civil war in Cuba
 Civil wars in Algeria, Mexico, . . .
 . . .

Figure 4—Plausible Scenarios for 2005–2020

The second step is to recognize that *each* political-military scenario (e.g., Iraq invades Kuwait and Saudi Arabia) has innumerable variations, differing in warning time, allies, military strategy, force levels, force effectiveness, weather, terrain, and even the algorithms assumed in war games used to assess capabilities. Thus, for each political-military contingency, there is an entire *scenario space* of operational circumstances. Exploring this scenario space would be of interest only to “modeling wonks” except that uncertainties about operational circumstances (e.g., warning time or the fighting effectiveness of defending allies) are very large and have profound effects on the military capabilities needed to prevail. Indeed, it is, if anything, more fruitful to examine a large scenario space for one or two threats than to examine a long list of threats with fixed assumptions about the operational circumstances of each.

Fortunately, with modern processing power, thoughtful design, and appropriate models, we can now conduct such scenario-space exploration quickly. Figure 5 illustrates some findings from such analysis. It shows one slice through the data base of simulated outcomes, one that shows effects of varying the time of deployment relative to D-Day (x axis), the nominal effectiveness of

tactical-aircraft sorties (y axis), and the suppression of tactical aircraft sorties (e.g., by chemical attack or dense air defenses) (z axis, into the paper), while holding many other variables constant. Figure 5, then, shows only 240 of some 100,000 outcomes of a simulated war with Iraq over Kuwait and Saudi Arabia, where green is a good outcome and red a bad one. It is assumed in these cases that Saudi ports and airfields are initially threatened (e.g., by irregular infantry with shoulder-fired missiles) and the Strait of Hormuz has been mined. In these cases, unless the United States deploys roughly a week or so before the war begins, it has to defer deployment of main forces and instead concentrate early activities on seizing and securing ports and clearing mines. This would give the advancing Iraqi forces nearly a week of additional time before the United States could fully engage them; the results turn out “red” (i.e., bad). We have, of course, identified elsewhere a number of force-improvement

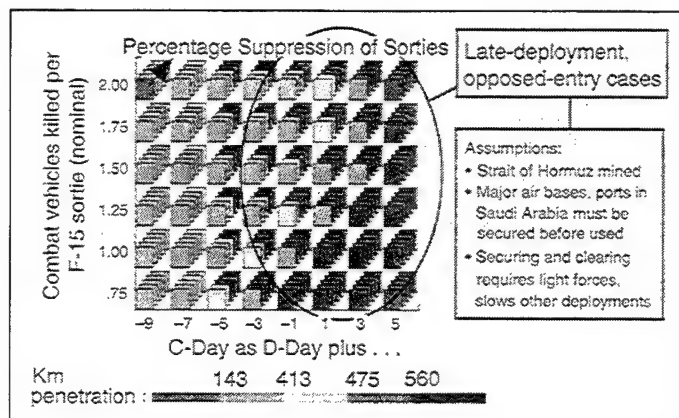


Figure 5—An Illustrative Contingency Analysis for the Persian Gulf

measures to mitigate these problems, but our point here is methodological.

Contrast Figure 5, which confronts forthrightly the huge uncertainties, with traditional analyses built around fixed assumptions. Again, Figure 5 is only one slice of the analysis of a single contingency. We consider the combined effects of many combinations of many parameters’ values. And we combine those, in turn, with multiple simulations of many other scenarios. We can view different slices of the outcome data base interactively by “turning knobs” on the computer display. Some of these knobs relate to measures of effectiveness.⁴ We believe this powerful new type of exploratory analysis—qualitatively different from traditional sensitivity analysis—is

⁴The measure of effectiveness used can have a strong impact on conclusions. For example, ability to conduct counteroffensives would highlight the value of Army units, while stopping an attack might be most easily accomplished with more air forces or allied ground-combat capability.

the appropriate way to test forces and postures for operational adaptiveness in war-fighting contingencies. Note the following:

- The objective becomes increasing the fraction of the scenario space in which U.S. forces would be able to prevail (with priority on the most important parts of the space), not increasing effectiveness for a few point scenarios.

Environment-Shaping

Environment-shaping entails using U.S. military forces to help create international security conditions such that it will be unnecessary to fight to protect our interests. Here we are making more explicit and methodical the familiar notion—reflected in Secretary Perry's recent statements—that U.S. force posture is, or at least ought to be, related to U.S. foreign-policy goals.

One important goal is promoting stability (e.g., by strengthening and enlarging alliances, and by building new cooperative relationships). Another goal is to prevent instability by reducing incentives for interstate competition and by deterring potential rogue countries from contemplating aggression. A related goal is discouraging regional states from attempting to compete militarily with the United States (e.g., by convincing them that the United States could trump any such effort).

Analyzing systematically a given defense program's contributions to environment-shaping begins by being reasonably precise in identifying environment-shaping objectives and the capabilities and activities that might contribute to them. To test alternative programs we use a version of multiattribute utility analysis, akin to methods used in business planning.

Our analysis so far has centered on future U.S. overseas military presence and the contributions of our closest allies. The result has been to demonstrate the potential leverage of low-cost increases in overseas military infrastructure, prepositioning, and especially foreign-military interactions (FMI)/security assistance such as training, exercises, and education. Such activities are regularly underfunded in all three of our key theaters (East Central Europe, the Greater Middle East, and East Asia). Yet funding these measures requires diversion of budget dollars, and the tradeoffs are sometimes painful or politically unpopular.

Admittedly, these methods involve subjective judgments. But any effort to bring analytical rigor to consideration of the international environment must necessarily do so, and in-depth research and analysis can increase the quality of such judgments. Such partially subjective methods are far better than excluding crucial "soft" issues from force planning, or treating them but relying on

impressions and loose conjectures about cause and effect. At a minimum, our approach allows decisionmakers and their staffs to question and change assumptions readily, observing—during the course of a meeting—how this affects conclusions about cost and effectiveness. As illustrated notionally in Figure 6, which reflects qualitatively the results of a recent study, decisionmakers may reach some of the same conclusions about priorities even when they approach the subjective-judgment problem from different perspectives. People with different perspectives make judgments about the value of various increments of capability or activity for improving the environment-shaping objective. The model then combines many such inputs and computes the relative cost-effectiveness. Figure 6 reflects notionally the conclusion mentioned above, that FMI/security assistance has the highest leverage, even if one can argue about how much value it has. Actual results vary with theater, the baseline assumed (e.g., how many forces are already forward-deployed), and the individuals consulted. Consensus is not always possible, of course, even on rank-ordering.

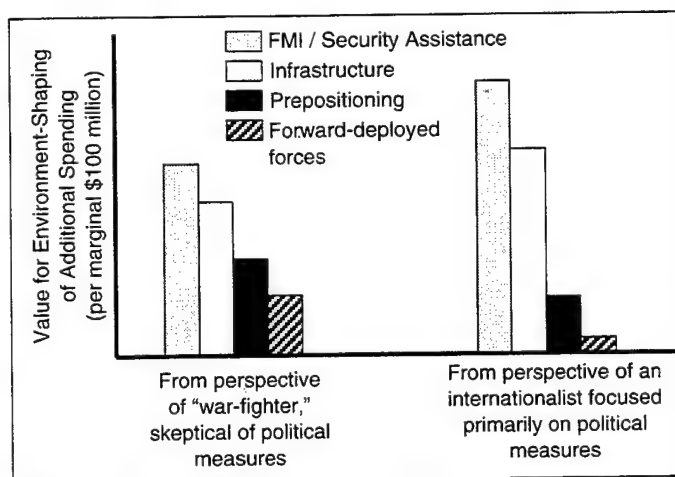


Figure 6—Notional Cost Effectiveness Conclusions About Contributions to Environment-Shaping

U.S. military superiority is one of the reasons we have an unrivaled opportunity to influence the direction and pace of international change. Examining carefully how alternative force postures might contribute to this goal should therefore be an integral part of the new defense planning framework. This will change the perceived importance of various research and development (R&D) and acquisition options. As we shall elaborate elsewhere, it will also highlight the need to strengthen and expand—not disengage from—overseas presence and coalitions worldwide, especially in Europe, East Asia, and the greater Middle East.

Strategic Adaptiveness

Even with skillful U.S. efforts to shape the environment, there is sufficient flux and uncertainty in interna-

tional politics and in technology that we cannot count on today's favorable strategic conditions to endure. DoD has seldom treated strategic adaptiveness as an explicit issue in assessing the defense program. It now seems critical to do so, because we are entering an era in which perceived military needs and military operations could shift drastically—perhaps repeatedly and in different directions—over the course of the next 20 to 25 years.

To evaluate strategic adaptiveness, we use the same basic methodology as for environment-shaping. We can identify many of the developments that might require adaptations. The list in Figure 7 distinguishes between some predictable discontinuities or branches, and some shocks. Following a simple logic of planning in the face of strategic uncertainty (Figure 8), we can also identify possible force-posture adaptations. Some can be well defined in advance as contingent substrategies for branch points; others—in response to shocks—will be more ad hoc, and more dependent on flexible hedge capabilities. Some of the hedge programs are in process (e.g., R&D on ballistic missile defense); others are arguably underfunded (e.g., technology and systems for swift mine clearance from sea lanes).⁵

Branches

- Korean unification
- Chinese military buildup and threatening behavior
- NATO expansion
- Defense budget
- Proliferation of missiles, weapons of mass destruction, inexpensive air defenses, advanced mines, . . .

Shocks

- Japan "goes independent"
- New Arab-Israeli war
- Hong Kong situation explodes, spreads
- Russia moves against Baltic states, Ukraine, or Poland
- "Surprise" cuts in defense budget, disrupting program
- Revolution in Saudi Arabia
- Actual use of WMD against the U.S., its forces, or allies

Figure 7—Illustrative Plausible Branches and Shocks

One benefit of introducing a strategic-adaptiveness test would be to help protect innovative experiments by the military departments that might otherwise be endangered by current exigencies in a budget crunch. These include arsenal ships, the Marines' Sea Dragon concepts, light and lethal Army units, and joint mastery of long-range precision strike. In this regard, it is troubling to note recent congressional actions cutting funding for

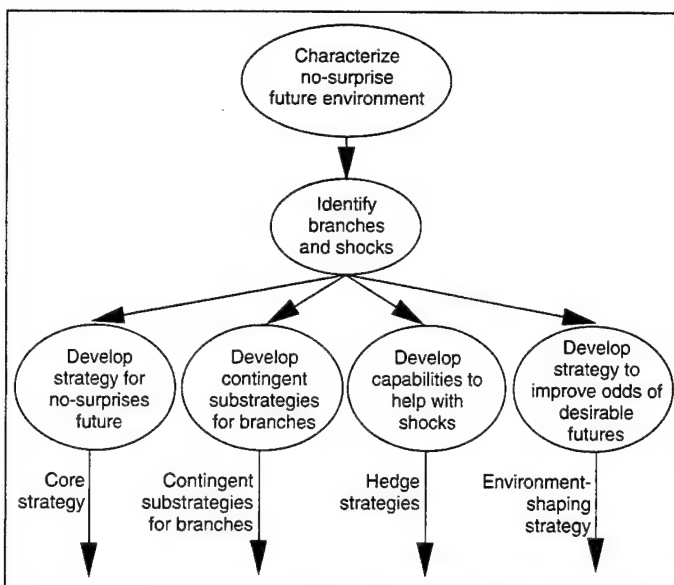


Figure 8—A Logic for Strategic Planning Under Uncertainty

advanced concept technology developments (ACTDs), the very kind of activities that an emphasis on strategic adaptiveness would promote.

Integration Using Portfolio Methods

Our methods create a more complete set of tests for assessing alternative force postures: war-fighting capabilities, environment-shaping, and strategic adaptiveness. But there remains the challenge of integrating, or *balancing*, these three considerations. Integration is what our top civilian and military leaders attempt earnestly to do. But it is not easy, and the leadership needs a new concept and method for unifying the strands.

We believe that an *investment portfolio* is the right metaphor. Like individuals and firms, national defense must balance multiple goals, stretching from the present day to the distant future, with numerous risk-benefit considerations in mind (Figure 9). As well, national defense, like the financial world, has a variety of instruments for achieving these objectives (Figure 10). The challenge is to assemble a portfolio of defense assets that best achieve our national goals, both today and tomorrow. Just as a financial investor normally wants many different types of stocks, bonds, and other investments as a function of its financial purposes, so also DoD will want a diverse portfolio of military assets and activities, as a function of its strategic purposes. The question is how to determine the composition of the portfolio.

A business manager must revisit the portfolio continually to assess what shifts among investment instruments are indicated in light of changes in goals or the external environment. Similarly, if near-term threats seem worrisome, then the Secretary of Defense may want to heavily emphasize contingency capability, with environment-

⁵The American industrial base is, of course, an enormously valuable hedge. In only a very few instances, however, does the DoD need to take special protective measures.

<u>Financial-World Concerns</u>	<u>Defense-Planning Concerns</u>
Long-term capital gains	Restructured and recapitalized forces for the mid to long term
Uncertainty about when to plan to cash in gains (end of expansion cycle, retirement age, . . .)	Uncertainty about when new forces will be needed
Short-term liquidity	Near-term readiness for contingencies and other military operations
Risk management on all time scales given uncertainties about market, economy, and government regulations	Risk management on all time scales given uncertainties about future threats, budgets, national strategies, and political constraints by Congress or foreign states

Figure 9—Parallels Between Financial- and Defense-Planning Concerns

<u>Financial-World Instruments</u>	<u>Defense-Planning Instruments</u>
Diversification	Broadening missions
Mergers and acquisition	Forming coalitions
Divestitures	"Letting go" of industrial base for obsolete capabilities
Special-opportunity investments	Addressing Achilles' heel problems
Hedging (R&D, stock options)	Hedging (e.g., R&D, prototype units)
Regular rebalancing of portfolio	Regular rebalancing of emphasis across contingency capabilities, environment-shaping, and strategic adaptiveness

Figure 10—Parallels Between Financial- and Defense-Planning Instruments

shaping secondary, and strategic adaptiveness little more than a reminder not to be caught off guard if strategic conditions change. By contrast, if the greater dangers seem to be in the mid or long term, then the Secretary would give relatively more weight to environment-shaping and strategic adaptiveness.

The strategic portfolio framework encourages decisionmakers to assemble options differently than in the past. Although Secretaries of Defense have long been concerned about adaptiveness and about tradeoffs between the short and long term, their planning framework and the measures of effectiveness used in the Planning, Programming, and Budgeting System (PPBS) are inadequate. In our construct, the Secretary would insist that every program review treat all three of the investment objectives—explicitly, in parallel, and with short-term versus long-term tradeoffs treated analytically. In many ways, this intuitively obvious proposal is radical. It would change the terms of debate and give

the defense program and its description a more long-term and strategic character.

Arguably, the portfolio approach would be suitable even in a seemingly stable and predictable world. In an era of uncertainty, even with our best efforts to manage the environment, it is the key to ensuring that our plans and our forces can be changed gracefully if need be.

CONCEIVING ALTERNATIVE FORCE POSTURES

This three-part adaptive framework, integrated by portfolio management, will not by itself generate alternative force postures. It will only test the options the policymaker or planner wishes to test. What should those alternatives be? Most of the current debate revolves around the two-MRC assumption, readiness, and force size as measured by numbers of divisions, carrier battle groups, and wings. But we believe the most important question facing the department involves modernization strategy, in the broadest sense. We see at least three philosophically different force-posture alternatives (or investment strategies) worthy of evaluation.

- *Conservatism, Near-Term Emphasis, and Expected Evolution.* This alternative would combine caution about technology's promises with emphasis on continuity in U.S. international engagement. By and large, it would feature a posture with only marginal changes in force structure, end-strength, "capital-to-labor" ratio, and overseas presence, and with little modernization beyond that needed to replace aged weapons systems and platforms. It would preserve the present balance among ground, air, and naval contributions to joint operations. It would reflect a belief that today's international security environment is relatively risky, with the longer-term future to be heavily discounted. This alternative, then, would stress near-term readiness and deemphasize long-term investment. Such investment would occur and be sustained only if budget levels were high, probably higher than today's. In that case, the posture would evolve over time.
- *Embracing the Revolution in Military Affairs (RMA).* Opposite this might be an alternative unreservedly embracing what some call the RMA. It would transcend current force configurations and increase reliance on long-range precision weapons and information dominance for waging war without deploying large traditional forces into war zones where they would be highly vulnerable to missile attack by both conventional and mass-destruction weapons. It would feature smaller, leaner, and dispersed maneuver forces and fires, rather than large armored formations. The approach would stem from the belief that the future of warfare is relatively clear and the need to prepare for it great. It would treat the current security environment as a respite from serious

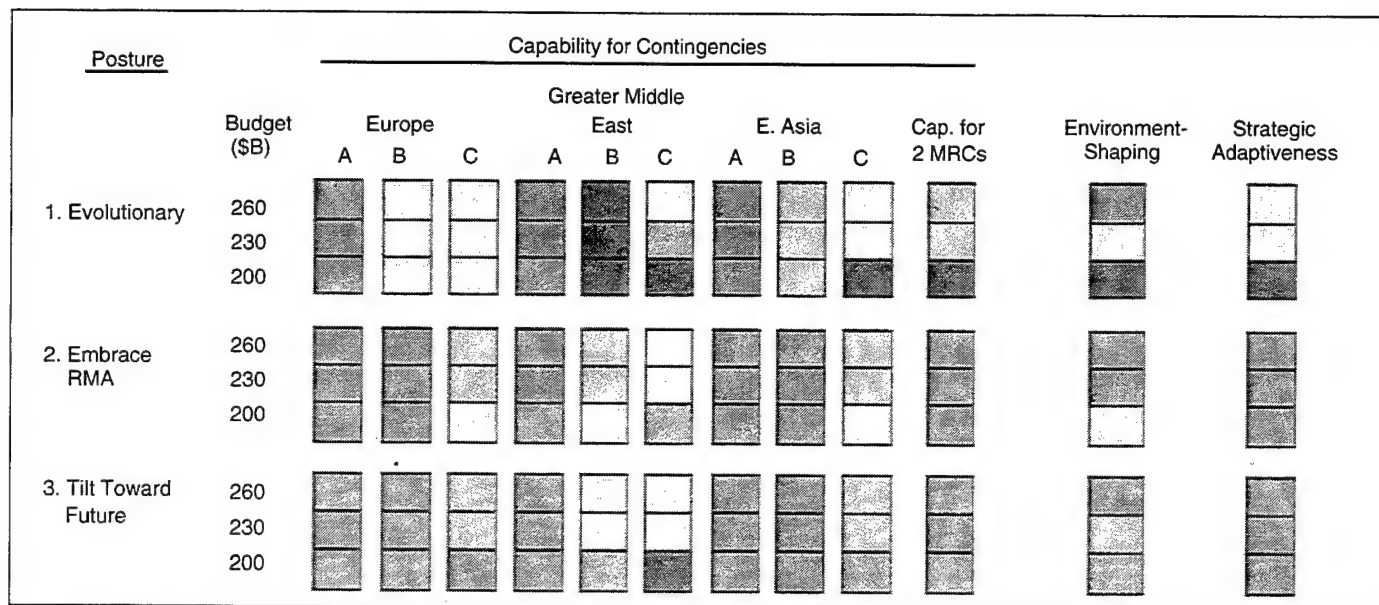


Figure 11—Notional Scorecard Assessment of Force-Posture Alternatives

threats and a window in which to invest toward what could be a more dangerous future. It would subordinate structure, readiness, and overseas presence to R&D and modernization.

- *Tilting to the Future, Cautiously.* A third alternative would be a compromise—a “tilt toward the future.” The United States would set a high priority on beginning the transition to a force structure with some of the same elements as envisioned under the RMA option—in particular, more emphasis on light units capable of rapid deployment, dispersed operations, and exploitation of long-range fires from both air forces and ground or sea platforms. The priority would be on using them to address the Achilles’ heel related to short-warning attacks and opposed entry. The pace of transition would be “deliberate.” Individual system choices would be adjusted over time depending on threat development and the success of newly fielded units. This alternative would maintain high levels of overseas presence for the sake of environment-shaping, although it would use somewhat different forces and reduce the number of people per unit. It would trade end-strength for R&D, innovation, and recapitalization, although less radically than option two.

The choices highlighted by these options should be central to the upcoming strategy review. Therefore, the options are good ones, though not necessarily the only ones, to test in the three-part framework we have constructed.⁶

⁶There are many possible “strategies” being discussed currently. These include reducing forward presence and relying upon power projection from the United States, relying more heavily on allies, trimming forces to meet a reduced, 1-1/2-war criterion, and various types of deliberate disengagement. National missile defense plays a prominent role in some of the strategies.

ASSESSING THE OPTIONS

Depicting a framework is one thing; employing it with analytical underpinnings is another. We have begun but not completed that. But we can describe broadly what we envisage, starting with a notional summary assessment of alternative force postures that would be shown after a full-scale strategy review. Figure 11 shows this as a familiar “stoplight scorecard” in which the colors red, orange, yellow, chartreuse, and green correspond to very bad, bad, marginal, good, and very good war outcomes, respectively.

This figure may seem complex at first, but it is actually nothing more than a distilled result of applying the strategic portfolio framework notionally (i.e., the colors shown are based on preliminary analysis).

- Each colored cell shows the assessment of a given force posture (row) for a given test (column).
- Along rows we have alternative force postures, which fall into three groups representing the three different portfolio philosophies mentioned above. For each we have versions for budget levels of \$260 billion, \$230 billion, and \$200 billion.
- The columns relate to the objectives discussed earlier (war-fighting capability, environment-shaping, and strategic adaptiveness). There are groups of columns for Europe, the Greater Middle East, and East Asia; within each of these there are three “cases” (A, B, and C), which test the force posture in increasingly demanding ways. The “A cases” are relatively favorable, akin to usual planning scenarios. The “B cases” involve short warning times and just-in-time rapid deployment with opposition, and the “C cases” involve having to fight our way back into a theater

and recover ground. These cases are composites of the many tens of thousands of cases examined in the scenario-space analysis. There is a column summarizing capabilities for various combinations of two simultaneous MRCs. The last two columns show how well the given force posture would score in shaping the environment and in strategic adaptiveness.

The idea, of course, is to test a given force-posture alternative in many ways and to provide a unified visual display of all the major factors policymakers need to integrate. Whether such a depiction is substantive or merely creative art designed to support preconceptions depends on the depth of the analysis that decides the color of each cell, using the methods described above. Providing that depth is the thrust of our current work.

By "adding up the colors," one can turn the spotlight chart into a graph of overall quality of the posture versus budget level. Figure 12 shows a notional result with one particular portfolio weighting of war-fighting capabilities, environment-shaping, and strategic adaptiveness. By contrast with Figure 11, it shows a band of values (also notional) for each option, the band representing uncertainty about the effectiveness of high-technology systems and their suitability for future wars. The hypothesis suggested by Figure 11's notional numbers is that option 1 (conservative evolution) may look reasonably strong for high budget levels but quite bad for lower levels. If one is confident about the "RMA options," then option 2 looks good generally, and dramatically so for lower budget levels. Option 3, the tilt-to-the future case, not surprisingly, is in the middle.

Figure 12 is not entirely notional. After all, a recapitalized force exploiting modern technology (e.g., precision strike, information systems, and mobility) would presum-

ably use fewer people and be more resilient to budget changes than the current force, which evolved during the era of large-scale sustained armored conflict. Also, our analysis indicates that military capabilities will drop rapidly with further decreases in the budget unless there is a substantial reengineering and reduction of infrastructure. In any case, debating the kinds of ideas displayed here would be useful. Our point is not that we know the answer, but rather that decisionmakers should be looking for the kinds of insights we offer notionally here.

SOME PRELIMINARY SUBSTANTIVE OBSERVATIONS

Having described our proposed framework and its methods, let us now share some preliminary results of using such analysis.

Near- and Mid-Term Capabilities Against Rogue Nations

For now, U.S. capabilities are very substantial, and U.S. forces will simply outclass any regional aggressor on the landscape. Indeed, our analysis of programmed future forces suggests the following:

- With sufficient warning time and reasonably effective allies, the United States should be able to defeat a classic armored invasion handily. In many cases, the United States should be able to handle two such invasions concurrently—so long as they are some weeks apart or, in some cases, even if they are more nearly simultaneous.⁷ Thus, classic armored invasions affecting U.S. interests "should be" obsolete. We will need to prepare for them indefinitely, so as to keep them obsolete. But they may not occur again, at least not in pure form as in the past and in our current plans.

Our adversaries, of course, can recognize all this as well. Thus, we must expect them to avoid classic armored invasions and instead adopt strategies involving fast, no-warning invasions with armored forces and/or various "asymmetric" tactics exploiting U.S. weaknesses:

- Current U.S. Achilles' heels primarily concern our limited capability to (1) rapidly seize and secure ports and bases that are not adequately protected by allied forces, (2) quickly clear sea lanes of mines, (3) employ air-to-ground munitions and other long-range fires against invading armies in difficult terrain (including urban sprawl) or bad weather, (4) conduct counter-offensives in such terrain, and (5) halt large dispersed threats (e.g., a broad-front infantry invasion).

⁷Some caveats: this statement assumes no ongoing LRCs or peacekeeping operations that materially interfere, wise allocation of military resources rather than a "piling on" against the first adversary, and a series of important adjustments in support forces and stocks.

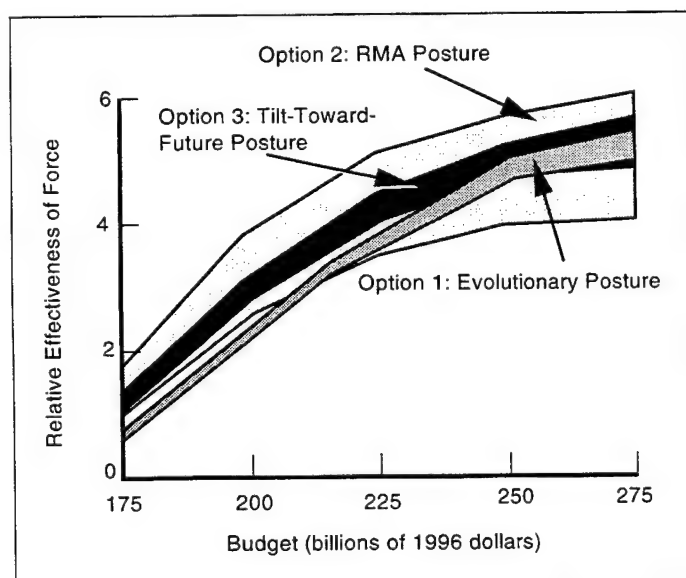


Figure 12—Capabilities Versus Budget Levels (Notional)

Fortunately, our analysis suggests that there are ways to remedy many of these problems:

- Many Achilles' heel problems (but not those demanding large-scale infantry-intensive efforts) can be cured by increasing allied capabilities and by exploiting the potential lethality of long-range bombers and other rapidly deployable or forward-deployed long-range precision fires involving ship-based missiles or advanced guns, tactical air forces, or mobile missile battalions. These steps would not require significant additional forces but would require mastering joint precision-strike operations and achieving high levels of situational awareness and information dominance. Other important measures would include forward-deployed countermine capabilities, counterinfantry munitions for high-altitude aircraft to use, and ensuring that allies' ground forces have modern anti-infantry artillery.

Weapons of Mass Destruction

There are other challenges, the most important being to neutralize enemy weapons of mass destruction (WMD). The WMD problem is critical because the threat of WMD could deter our intervention, deter threatened states from asking for assistance, or deter allies from cooperating. And, of course, WMD could cause major casualties. This would probably precipitate an extraordinarily destructive U.S. retaliation, but we cannot rely upon deterrence alone to evade the WMD issue—especially if adversaries are desperate, as the North Koreans might be in invading the South, or as any adversary might be once the United States and its ally had begun a counteroffensive. Thus, theater missile defenses and counterforce capabilities loom large on the priority list. But even with improved defenses, the WMD challenge tends to weigh in favor of a force posture and war plans that do not depend on dispatching large, densely packed U.S. forces into range of enemy WMD.

Sizing the Force and the Two-MRC Issue

The force-sizing debate currently revolves around the controversial "two-MRC criterion." This focus is misdirected. As noted above, our analysis shows that the U.S. has more than ample capability for two MRCs in favorable or only moderately degraded situations. But it would find itself severely stressed in even *one* MRC in worst-case situations (e.g., a multi-month counteroffensive after a North Korean surprise attack with chemical weapons had shattered South Korea's defenses).

Results of fighting two MRCs would also depend on military strategy at the time. In favorable cases, we might be able to win both conflicts quickly and decisively. In

others, we might hold and punish the aggressor in the second theater until, having defeated the first aggressor, we could turn our full attention to the second. Or we might be able to depend more on allies for one of the MRCs. In still other cases, we might find that fighting even one war would require months or years. It all depends. Thus, a two-MRC criterion, in and of itself, is quite ill-defined; it is not a sound basis for planning.

Nonetheless, if we must have a number, then DoD has it right: "Two" is the right one. It would be folly for the United States to announce a one-MRC (or even a 1-1/2 MRC) criterion, because such a strategy would give us pause before acting in crisis and would encourage aggressors to exploit the opportunity of our being engaged elsewhere.

Some believe that sizing the force for two MRCs is too expensive and unnecessary in the current era of moderate risk. The issue is not, in fact, affordability, because the U.S. defense burden is now quite low by historical standards, and dropping. The issue is need, because there certainly are many claimants for the marginal federal dollar. On this point, however, we offer the following insight from our framework:

- The most stressful criterion in sizing the U.S. force is probably environment-shaping, not war-fighting capability. The United States has interests in not two but three vital, unstable regions, and those interests are inexorably expanding (e.g., into East Central Europe and Southeast Asia). Thus, in sizing the force we must think about the need to fight an MRC in one region while deterring conflict and continuing to manage regional security in the other two. When one accounts for rotation bases, likely coalitional arrangements, and other practical features of force planning, this requirement may be even more demanding than fighting two MRCs against inferior adversaries.

The Role of Coalitions

Our framework highlights the role and importance of coalitions, since the analysis shows that the role of allies is a major variable in terms of war-fighting, environment-shaping, and responding to strategic shifts. The contributions of our most dependable allies should be explicitly recognized in our strategy, plans, and posture. Steps should be taken to strengthen our confidence that those allies will have the right forces and be prepared to use them. There is great leverage available in doing so.

Readiness Versus Investment, Good and Bad

DoD has been criticized because of alleged readiness problems despite the high priority that all recent

Secretaries have placed on readiness. They have been intent on not allowing a repeat of the 1970s, during which U.S. forces became "hollow." This concern is laudable, and, as a result, today's forces are in fine shape except for the severe stress due to high operational tempos caused by such demands as Somalia, Rwanda, Haiti, Bosnia, Liberia, the Persian Gulf, and Korea.

In our view, however—in part because our framework constantly forces the issue of short term versus long term—the priority placed on readiness has become excessive. Clearly, the United States needs active forces to be in a high state of readiness. But how much is enough? In the absence of more severe regional threats than one can currently foresee, we might well be able to trade some active high-readiness force structure for moderate-readiness reserve structure (and less low-readiness ground-force reserve structure) and use the savings for investment. This would especially be so if we succeed at strengthening and leveraging the capabilities of allies. The premium for readiness is on rapid-deployment forces and naval forces, but not the entire current active force structure. Yes, a worst-case war requiring a larger active force might arise, but such a war would probably play out over months or years. Must we maintain active forces against such a contingency, or can we make better use of reserves and plan for a force buildup when and if the need arises?

The Gordian Knot: Thinning, Not Cutting, Force Structure

A core problem facing the Department is the apparent resistance to reducing active force structure. The current structure is already underfunded, the notorious acquisition holiday has already been too long, and there is arguably a need to begin a fundamental, perhaps revolutionary, recapitalization. The real questions are how much and how fast. This said, we must expect that DoD's funds will remain severely limited and that even heroic efforts to reduce infrastructure and acquisition overhead will have less payoff than optimists expect, except perhaps over the long term. This implies to us that force structure must be a significant bill-payer for what is needed. Our analysis indicates, however, that this need not be nearly so troubling as it often is. Given the enormous improvements in command, control, communications, computers, intelligence, surveillance, and reconnaissance (C⁴ISR); mobility; and lethality of systems, and given the modest nature of current regional threats, it should be possible to reengineer forces so that smaller units take on the functions that previously were accomplished by larger units (e.g., brigades taking on division functions). Further, some functions (e.g., running ships) should be possible with fewer people. All of this would be normal reengineering in an industrial setting.

It follows that the terms of debate should be focused not on reducing major formations (e.g., reducing from 10 to 6 active army divisions, or from 11 to 6 carrier battle groups), but rather on reducing end-strength, changing what constitutes our major formations, and altering the active/reserve mix. It may well be that we should have 10 army divisions, but with 1/3 fewer people and more emphasis on light forces and long-range fire; that the "capital ships" of the future should include Aegis cruisers and arsenal ships rather than only carriers; or that active Air Force wings should be fewer or smaller than in the recent past.⁸ None of these measures would constitute disengagement or disarmament, which would have harmful effects on the security environment. If the United States truly improves its posture by reengineering, we should have enough influence to convince our adversaries and allies of that, even though they might at first equate reduced numbers with disengagement.

ON THE NEED FOR UNUSUALLY STRONG LEADERSHIP

As we have indicated, we believe that the biggest challenges are three: (1) breaking with the point-scenario, threat-based planning of the past, (2) shifting the focus of the program so as to contribute more to the "strategic" objectives of environment-shaping and strategic adaptiveness, and (3) beginning to transform and recapitalize the force posture for the next—and likely very different—era of warfare, which should be distinguished from merely modernizing by replacing old equipment. Such changes are unlikely to happen easily.

It is possible, of course, that the DoD is a unique organization immune to the maladies that affect other nations' armies, corporations, and government agencies. Perhaps the military Services will push ahead with all deliberate speed in making the fundamental planning and doctrinal changes that are needed. These changes are plausible if the defense budget is raised enough so that there are "new" funds. Or perhaps the Services will even sacrifice current force structure to free the funds necessary for recapitalization. However, in our view, such a rosy scenario is at best a theoretical possibility. Far more likely is that, without firm guidance to the contrary, the Services will hold onto force structure tenaciously. When budget crunches occur, one after another, important experiments will be routinely deferred or forgone, and some next-generation weapon systems as well. The future will be lost through "salami slicing."

To put things a bit differently, we are on the one hand greatly encouraged by the vigor and innovation being shown in all of the Services. All the building blocks

⁸The Air Force has already reduced the size of its fighter squadrons.

for transformation and recapitalization are visible, as the result of enlightened R&D and the most talented armed forces that the world has ever seen. However, sweeping change is painful and disruptive; it does not occur without strong top-level leadership insisting upon it. In DoD, it will require exceptional and sustained leadership by the Secretary of Defense and the Chairman of the Joint Chiefs.

The alternative may be to find ourselves in 20 years with a run-down version of a military force structure suit-

ed to the 1980s rather than a first-rate, versatile, and adaptive military force designed for the next century. If we build the latter, we stand a better chance of staying in front of would-be adversaries and wanna-be hegemony, and we can guide international and technological change. In such a case, the world might go decades without the kinds of major wars that so darkened the history of the 20th century.

This paper draws on much past research. See in particular the RAND book *New Challenges for Defense Planning: Rethinking How Much Is Enough*, Paul K. Davis (ed.), MR-400-RC, 1994, 769 pp., \$20.00, ISBN: 0-8330-1527-3. RAND is a nonprofit institution that helps improve public policy through research and analysis. Results of specific studies are documented in other RAND publications and in professional journal articles and books. To obtain information about RAND studies or to order documents, contact Distribution Services (Telephone: 310-451-7002; FAX: 310-451-6915; or Internet: order@rand.org). Abstracts of all RAND documents may be viewed on the World Wide Web (<http://www.rand.org>). Publications are distributed to the trade by National Book Network.

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Appendix B1 – *Framing the Issues – The Methodology*
Bob Statz, Booz Allen & Hamilton

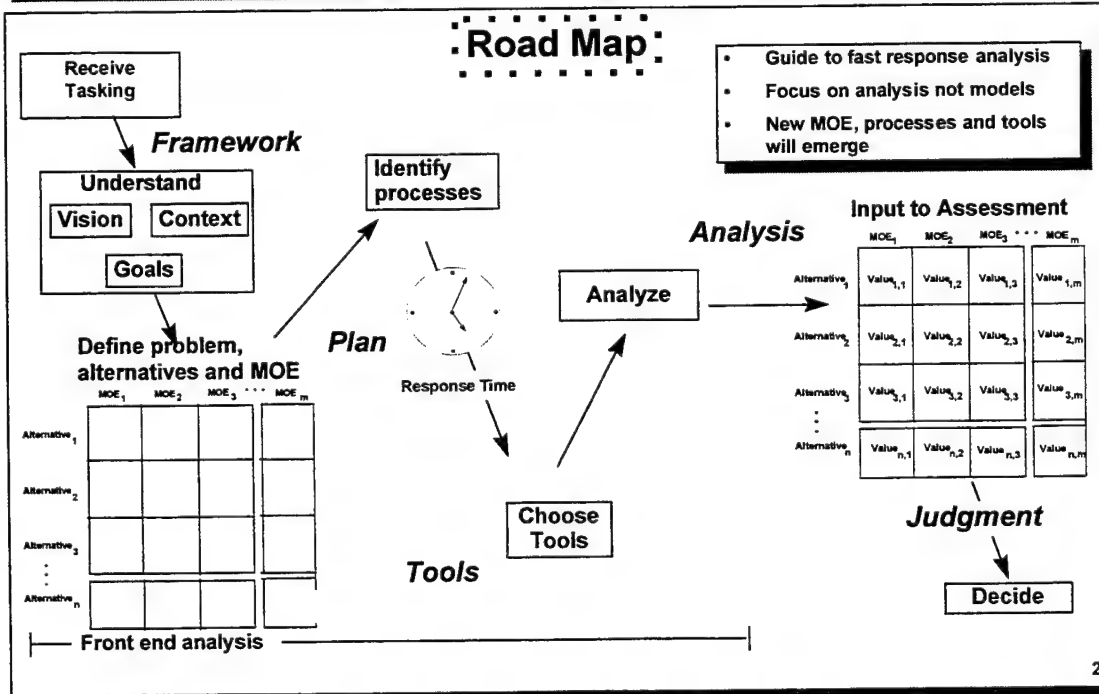
Framing the Issues

Some Considerations

**MORS Mini-Symposium
1 Oct 1996**

1

•An analyst may follow this road map to analyze a tasking. The key elements for quick response analysis focus most on the front end, on structure and content, and less on mechanics for analysis.



2

We believe that the key elements for performing quick response analyses are listed below. Next, we will discuss each point in detail.

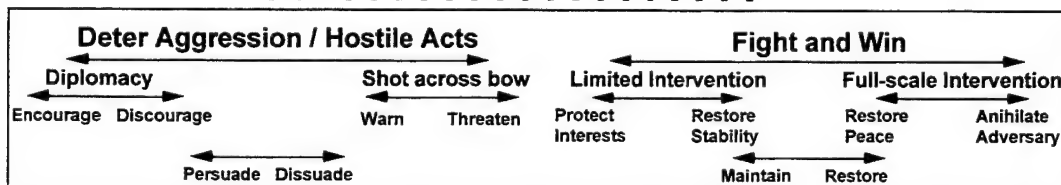
. Key Elements .

- **FRAMEWORK** - Understand the environment relevant to the question.
 - *Examine the spectrum of Military Goals*
 - Identify the Context
 - » Understand the nature of the debate
 - » Identify applicable variables and constraints
 - Develop an objective (quantitative) Vision of the future battlefield
- **PLAN** - Present the analysis to the decision maker early.
 - Define the issue/problem
 - Identify alternative solutions
 - Identify MOE to compare alternatives
 - Identify the underlying Processes
- **TOOLS** - Help the analyst produce and analyze MOE.
 - Determine Time available to conduct the analysis.
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 - » Models
 - » Games
 - » Analysis support tools
- **ANALYSIS** - Conduct the Analysis and Assessments

3

The analyst should keep the spectrum of military goals in perspective. Analysis of the tasking should align with the appropriate goals. The spectrum below is notional, based on our interviews and discussions. It should be expanded and modified to suit DoD needs.

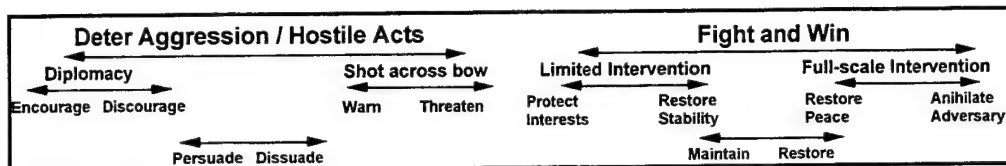
. Spectrum of Military Goals .



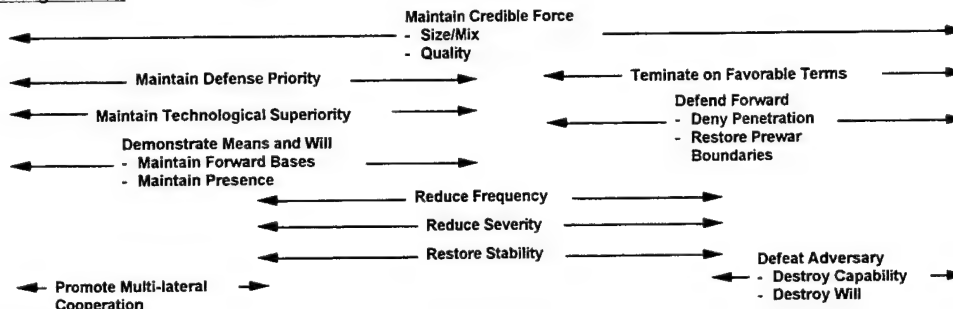
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•The spectrum of military goals exists within any scenario in a hierarchy of strategic, operational and tactical levels. Appropriate goals at each level in this hierarchy will help the analyst focus the analysis.

Military Goal Hierarchy:



Strategic Goals:



Operational Goals:

Tactical Goals:

5

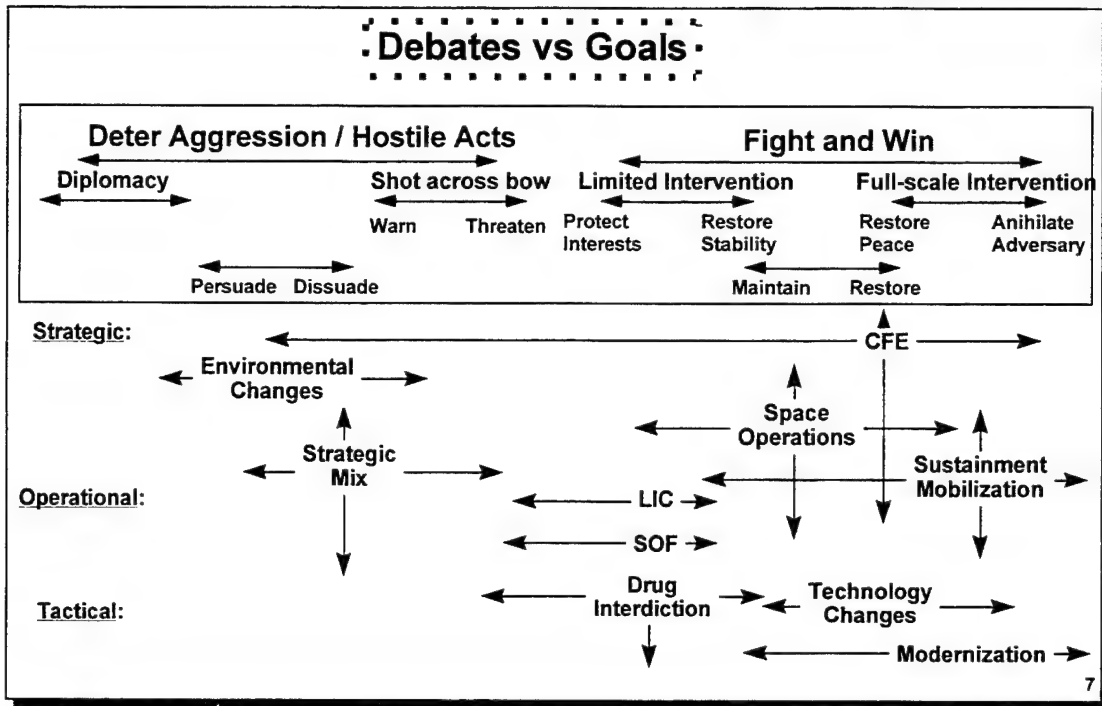
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The issues associated with debates uncovered during interviews cover the complete spectrum at all levels of the Strategic - Operational - Tactical hierarchy. The positioning of the debates below suggests the center of its focus, but the arrows suggest the depth and breadth of its issues.



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Key Elements

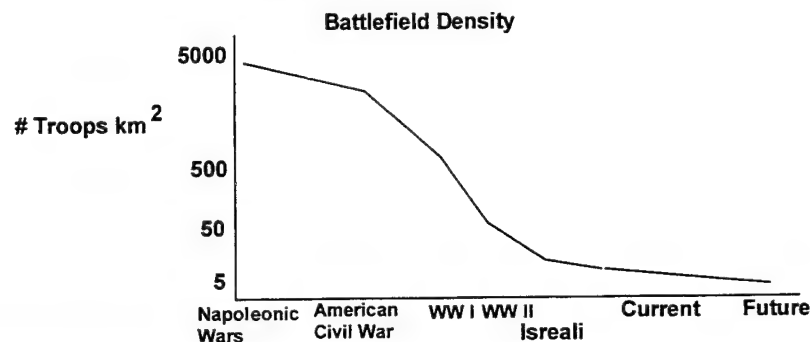
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A set of hypotheses covering concepts important to understanding of future conflict should be postulated. These will guide the analyst's thinking and help structure and quantify the military judgment applied in the assessment of critical issues.

Develop a "Vision" of the Battlefield

Hypothesis: Density on the future battlefield will be nearly an order of magnitude more dispersed than today due to the threat of advanced munitions. This increased dispersion will place a premium on C3 connectivity, under all conditions of electronic warfare, and concealment.

Discussion: The impact of indirect artillery fire was to disperse forces from positions observable to the enemy. With new sensors and overhead assets, a larger proportion of the enemy forces are observable and subject to accurate indirect fire. Improved "cluster" type munitions have an increased lethality which practically guarantees significant losses within the munitions footprint. Two responses are to harden the force or increase dispersion.



9

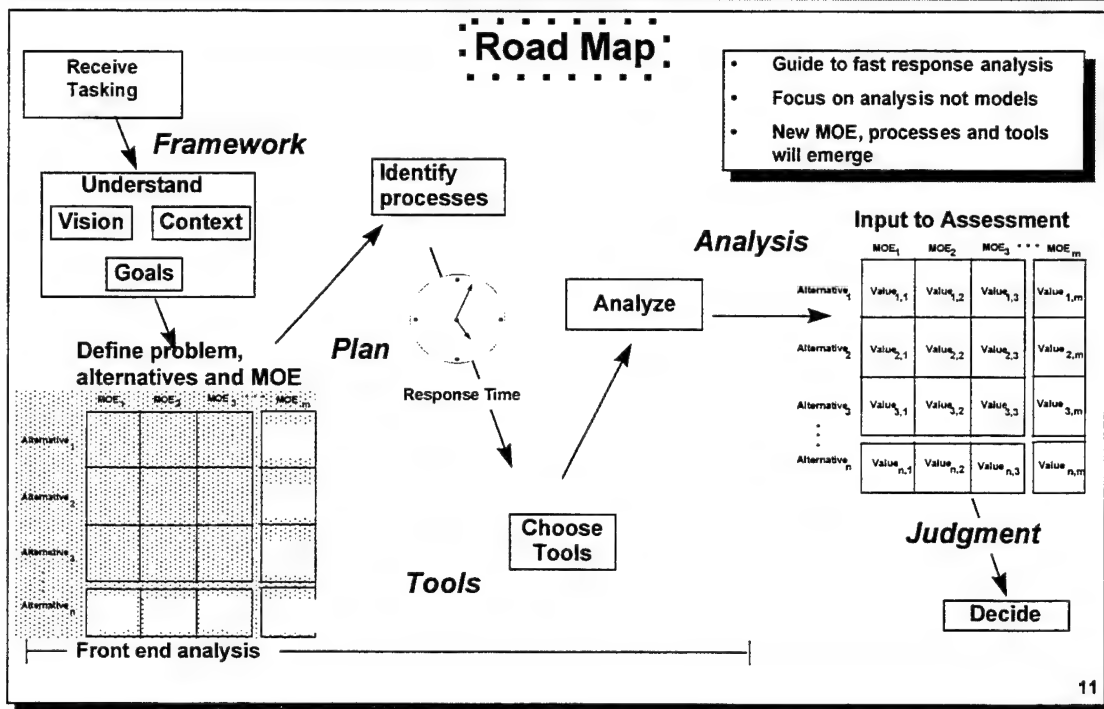
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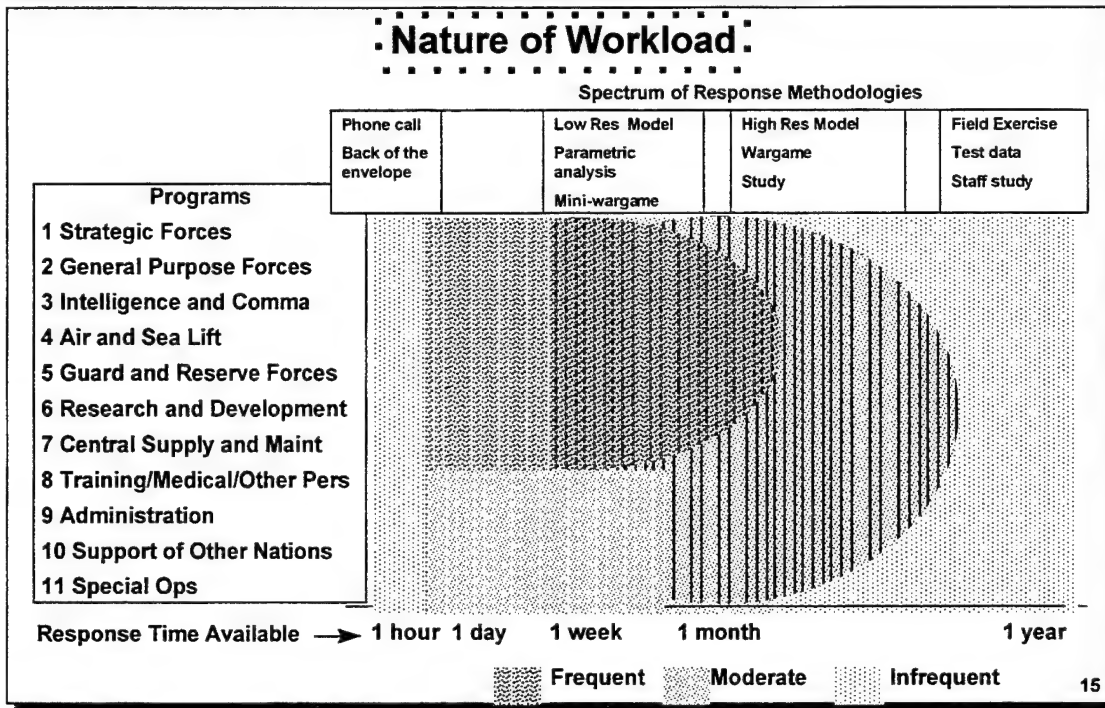
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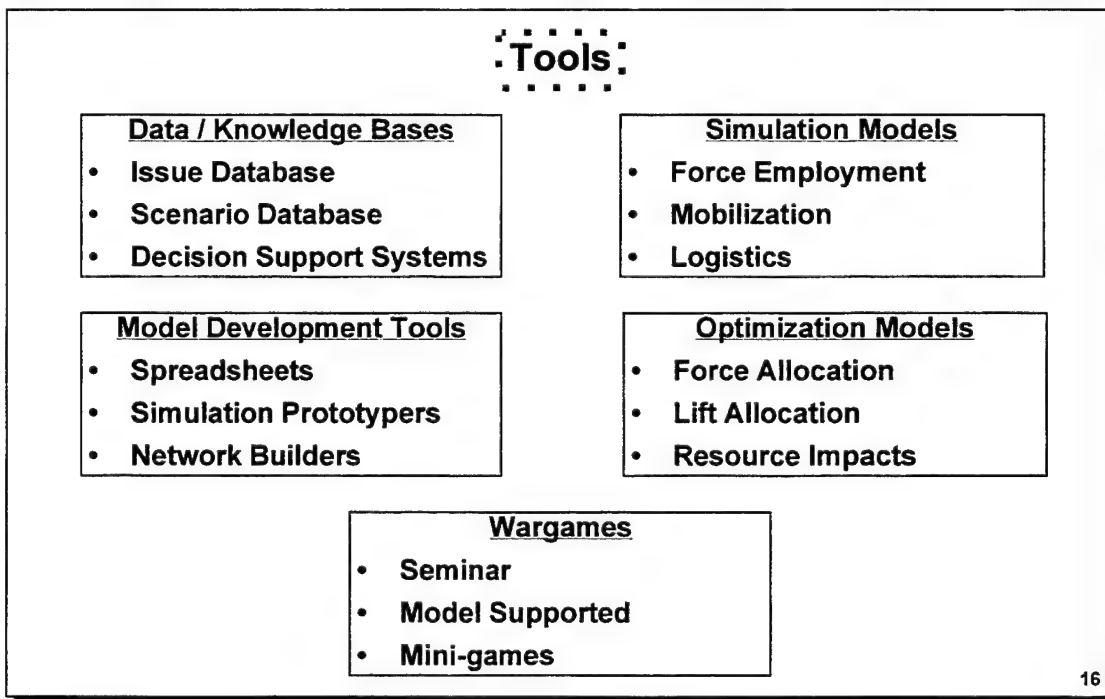
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14

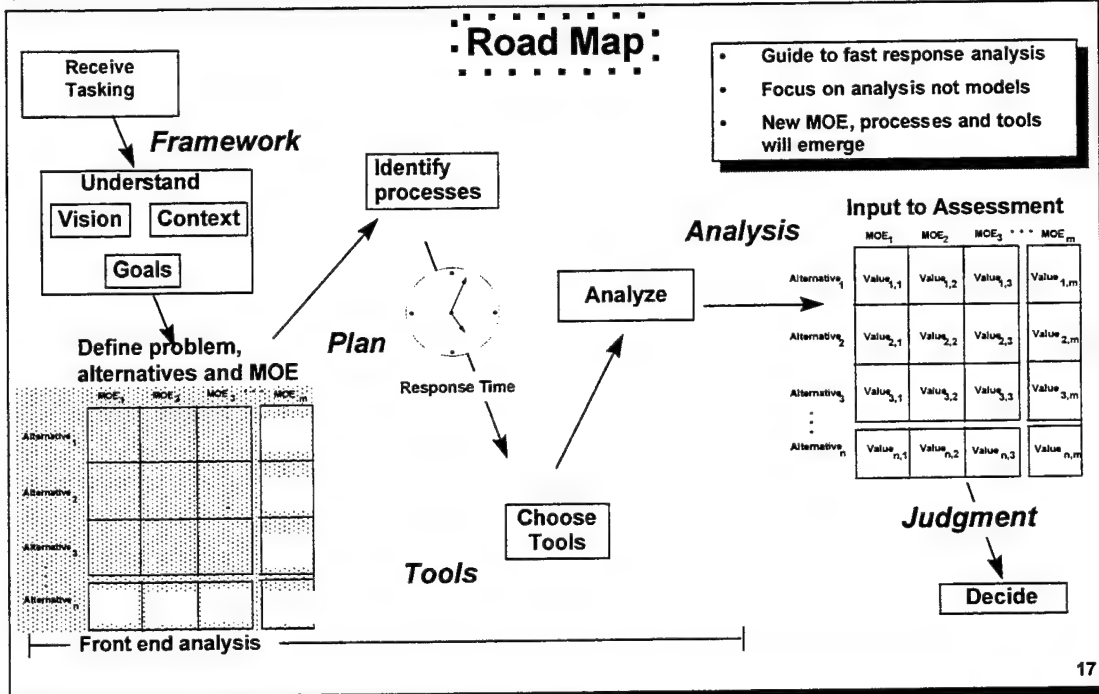
Characterizing the workload for quick response analysis required several cuts. The picture below suggests the relationship of frequency and response time for taskings to Programs and possible analytic approaches.



• Many different kinds of tools can represent the process of interest. The analyst needs tools that provide adequate resolution and that perform in the required response time.



•An analyst may follow this road map to analyze a tasking. The key elements for quick response analysis focus most on the front end, on structure and content, and less on mechanics for analysis.



To investigate models for quick response analysis, we must answer these questions.

More About Tools:

- What models or attributes of models should be incorporated in a quick response analysis system?
- What tools should be part of analyst's tool kit?

Listed below are attributes important to all models or tools to be used for analysis. Separately noted are attributes particularly useful for quick response analyses tools. It is also important to note that the total set of tools should provide coverage of the full range of issues anticipated.

Model Attributes

"Models are for thinking with."

Sir M. G. Kendall

"Everything should be made as simple as possible but no simpler."

A. Einstein

Desirable Attributes of All Models:

Relevance - Fits vision of future battlefield, goals and debates

Understandable - Both the analyst and the decision maker readily understand model and results

Verifiable - Accurately illustrates relationships of observable parameters and decision variables

Reproducible - Results are reliable and repeatable under varying conditions

Expandable - May be quickly modified to meet changing needs

Desirable Attributes of Quick Response Models:

Appropriate Simplicity - Military realism maintained at first order

Low Resource Needs - Minimal set-up, analyst, and computation time.

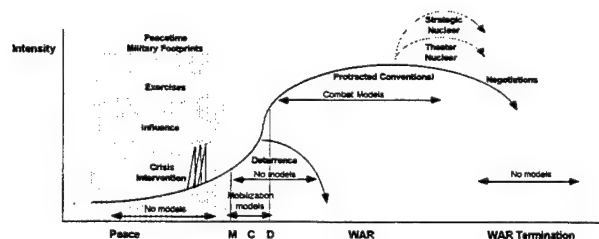
Responsiveness - Rapid run time and easy change of parameters for sensitivity analysis

Bicycle Principle - Like riding a bicycle, once you learn how to run the model, you will always be able to run it

19

There are many ways to consider model coverage. When we look at the spectrum of conflict over time, we see gaps in model coverage. We believe that our approach will not only show the gaps but identify which ones need to be filled.

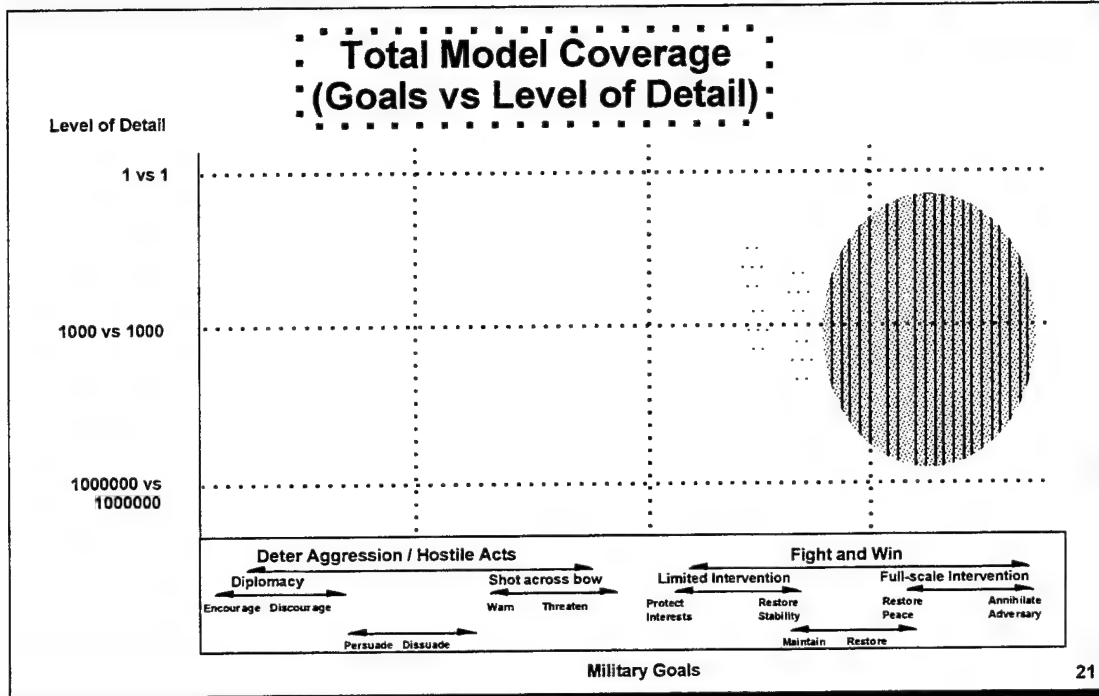
Model Coverage of Military Missions



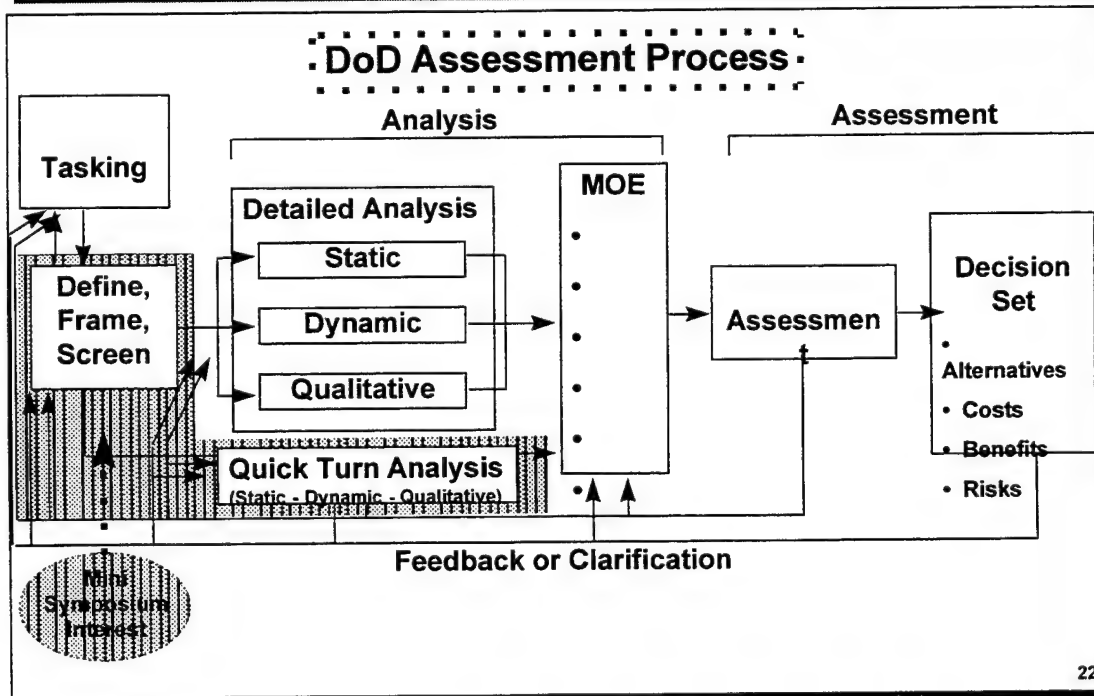
Source: CAPT Larry Seaquist

20

In fact, we expect nearly all existing models will be found in the same region.



From discussions with DoD Analysts, we obtained this view of the assessment process.



Appendix B2 – *What is the Value of BDA*
Doug Williams, Booz Allen & Hamilton

The Process

Quick Response Analysis of the Battle Damage Assessment Process

Prepared for
Joint Staff, J8
CAPT Jake Shuford, USN
by
Booz·Allen & Hamilton Inc.
Doug Williams (703) 902-4756
Bill Thoet (703) 902-6702

The Steps

- Receive Tasking
- Frame the Issue - Understanding
- Consider Response Time
- Define the Problem and Develop MOE
- Choose Methodology/Tools
- Analyze
- Input for Assessment
- Decision

Receive Tasking

“Determine the value of Battle Damage Assessment (BDA: the re-shoot decision) for strike operations.”

Frame the Issue - Understanding

- The Debate: C4ISR (BDA is small piece) will provide more highly effective, *and efficient*, force
- From Nimble Vision
 - “What is impact of integrating BDA in the ATO cycle?”
 - Assumption that BDA is perfect: What if it isn't?

Example

- Shoot five cruise missiles with $P_{SSK}=0.7$ yields $P_{Kill}=0.998$, but always expends 5 missiles
- But if a “look” is taken after each shot, still achieve $P_{Kill}=0.998$ and only expend, on the average, 1.43 missiles
- But this assumes that an “image” is available for each “look” and that the probability of correct assessment is 1.

Consider the Response Time

- “Need insights within two weeks.”
- Time available scoped the analysis to look for “knees in the curve,” the break points
- Decided to conduct parametric analysis

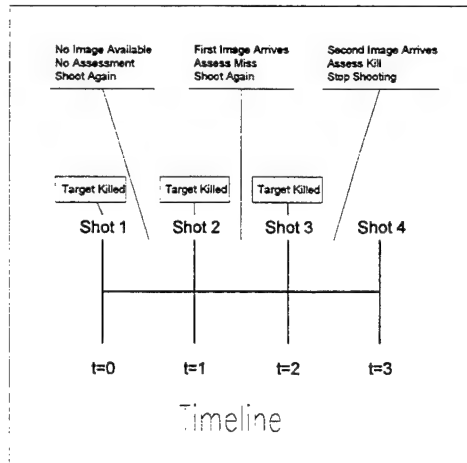
Plan the Work

Define the Problem/Develop MOE

- Developed timeline and transition diagram (The Model) that describes Shoot-Look-Shoot process
- Independent variables are P_{SSK} (probability of single shot kill), R_{BDA} (the probability of receiving an “image” for assessment), and P_{BDA} (the probability of making a correct assessment).
- Dependent variables are P_{kill} (cumulative probability of kill) and Shots (number of shots required to receive P_{kill})
- MOE are Shots per Kill and Percent Effectiveness Increase for SLS over Shoot-Shoot for an equal number of shots

The Firing Process

Timeline Example

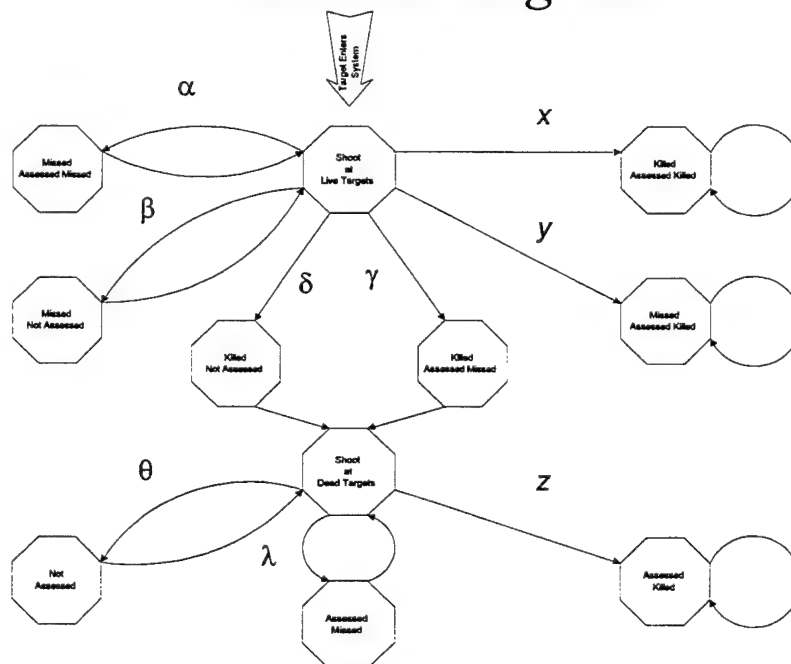


- Target killed on Shot 1
 - No image for assessment
 - Shoot again
- Target hit again on Shot 2
 - Image arrives before Shot 3
 - Incorrect assessment made
 - Shoot again
- Target hit again on Shot 3
 - Image arrives before Shot 4
 - Target assessed killed
 - Stop shooting
- Result of no assessment or incorrect assessment
 - Wasted 2 weapons
 - Wasted 2 time units

7

The Firing Process

Transition Diagram



8

Choose Methodology/Tools

- Parametric analysis of Markov Firing Process
- Spreadsheet with add-in graphics and stochastic modeling packages
- Symbolic math COTS package
- Text book on stochastic processes

COTS

Microsoft Excel
Harvard Chart XL
Crystal Ball
MathCAD
Mathmatica

Analyze

- Used Markov transition diagram to develop expressions for P_{Kill} and Shots
- Used symbolic processor to find closed form solutions to equations
- Used spreadsheet to develop graphs (using the equations) to compare SLS with SS
- Found “knees in the curves” for when SLS becomes more efficient than SS

Expressions for P_{Kill} & Shots

$$P_{\text{Kill}} = \sum_{k=1}^n P_{\text{SSK}} \cdot (\alpha + \beta)^{k-1}$$

$$\text{Shots} = 1 + \left[\sum_{k=1}^{n-1} \left[(\alpha + \beta)^k - \sum_{i=0}^{k-1} (\alpha + \beta)^{k-1-i} \cdot (\gamma + \delta) \cdot (\theta + \lambda)^i \right] \right]$$

Where:

$$\alpha = (1 - P_{\text{SSK}}) \cdot R_{\text{BDA}} \cdot P_{\text{BDA}}$$

$$\beta = (1 - P_{\text{SSK}}) \cdot (1 - R_{\text{BDA}})$$

$$\gamma = P_{\text{SSK}} \cdot R_{\text{BDA}} \cdot (1 - P_{\text{BDA}})$$

$$\delta = P_{\text{SSK}} \cdot (1 - R_{\text{BDA}})$$

$$\theta = (1 - R_{\text{BDA}})$$

$$\lambda = R_{\text{BDA}} \cdot (1 - P_{\text{BDA}})$$

$$n \geq 2$$

$$0 \leq \alpha, \beta, \gamma, \delta, \theta, \lambda \leq 1$$

$$\alpha + \beta \neq 1$$

$$\theta + \lambda \neq 1$$

11

BDA Equations

- MathCAD Example

Battle Damage Assessment

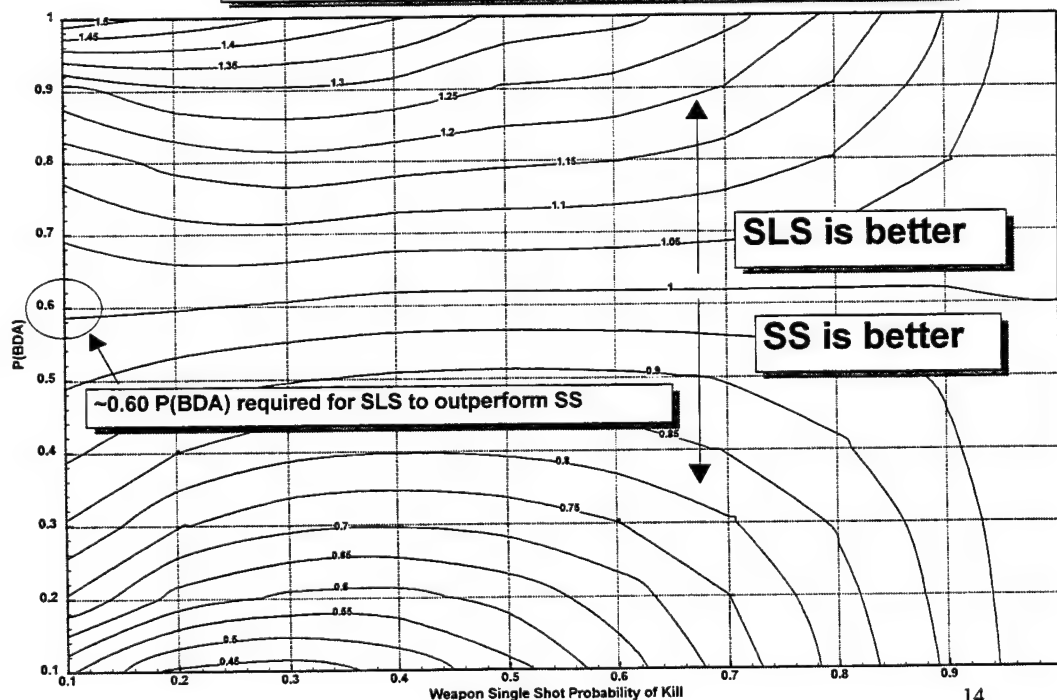
Mathematical Expressions

$$P_{Kill} = \frac{P_{SSK}}{P_{SSK} + R_{BDA} - P_{BDA} \cdot R_{BDA} - P_{SSK} \cdot R_{BDA} + P_{PBA} \cdot P_{SSK} \cdot R_{BDA}}$$

$$Shots = \frac{P_{SSK} + P_{BDA} \cdot R_{BDA} - P_{BDA} \cdot P_{SSK} \cdot R_{BDA}}{P_{BDA} \cdot R_{BDA} \cdot (P_{SSK} + R_{BDA} - P_{BDA} \cdot R_{BDA} - P_{SSK} \cdot R_{BDA} + P_{BDA} \cdot P_{SSK} \cdot R_{BDA})}$$

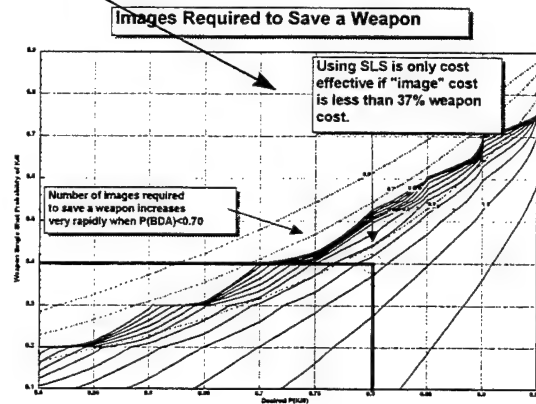
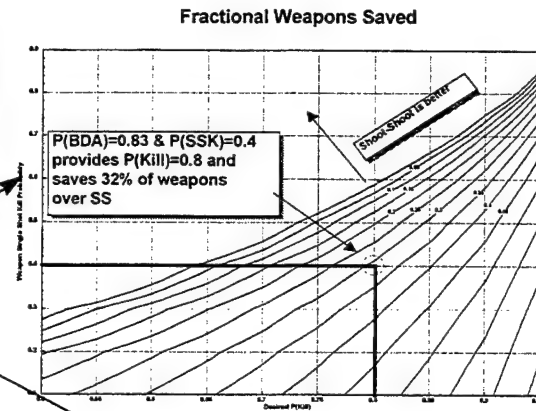
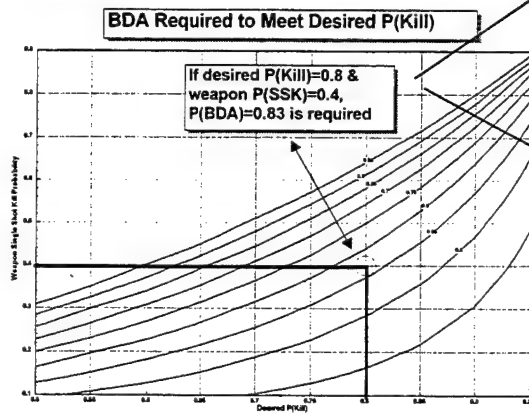
13

Shoot-Look-Shoot versus Shoot-Shoot P(Kill) Break Even Point



14

A Weaponneering Example



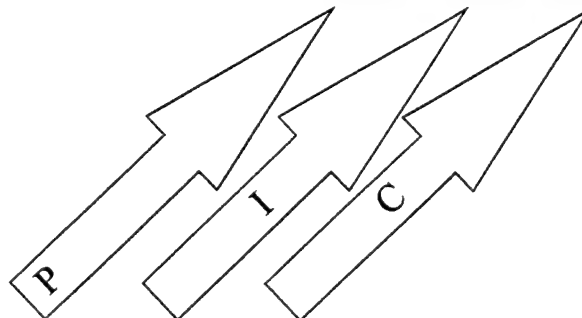
Trade Space Expression

Interpretation

Logistics

BDA System

$$\text{Shots per Kill} = \frac{1}{P_{SSK}} + \frac{1}{R_{BDA} \cdot P_{BDA}} - 1$$



Input for Assessment

- Given that an “image” is available to make and assessment, probability of making a correct assessment must be $>.6$ before SLS becomes more effective than SS
- Efficiency equation for SLS

$$\text{Shots per Kill} = \frac{1}{P_{SSK}} + \frac{1}{R_{BDA} \cdot P_{BDA}} - 1$$

Decision

- THE ANALYST PRESENTS THE INFORMATION
- THE DECISIONMAKER MAKES THE DECISION

Summary

Issue Category	Logistics/C4ISR/Force Trade Space
Receive Tasking	Determine the value of BDA
Response Time	2 weeks
Frame Issue	"What is impact of integrating BDA in the ATO cycle?" "What if BDA is not perfect?"
Plan the Work <ul style="list-style-type: none"> Define the Problem Alternatives Variables MOEs 	<ul style="list-style-type: none"> Developed transition diagram model Parametric Analysis of full range of values 3 independent, 2 dependent Shots per Kill & Percent Effectiveness Increase
Methodology/Tools	Markov Firing Process COTS
Analyze	Combined methodology & tools to develop equation set, used spreadsheet and charting package to analyze results
Input for Assessment	Insights for trades in logistics/C4ISR/Force Trade Space
Decision	

Appendix B3 – *The Art of MOE Development*
Dr. Roy Rice, Teledyne Brown Engineering

THE ART OF MOEs
OR
IN SEARCH OF THE HOLY GRAIL !!

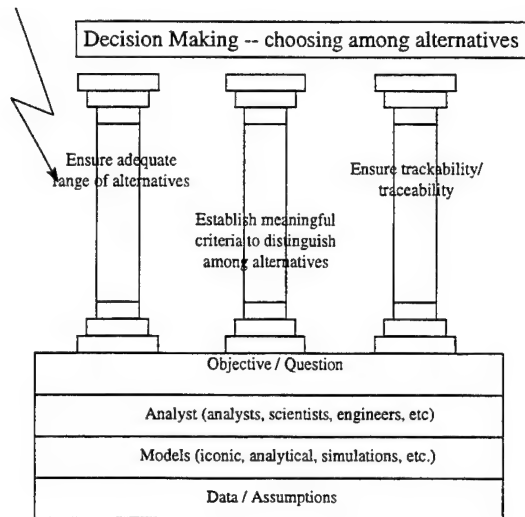
by
Roy Rice
2 Oct 96

TODAY'S SERMON

- This ain't the FIRST time.
- Captain Kangaroo said, "Put on your thinking caps."
- Scientific Method - Back to 8th grade science class
- If it ain't combat, what is it?
- Strategies-to-Task ain't all it's cracked up to be
 - but it's a real good start
- The \$64 question — what's the Trade Space?
- What does the Final Chart look like?
- THE HOLY GRAIL!

*Role of the
Analyst*

FIRST TIME



FIRST TIME

- MGen John Grinalds - DJ8
- Same old discussions - new buzz-words
- Where have you all been?

“PUT ON YOUR THINKING CAPS”

- Roske E-mail
- MGEN John D. Robinson Letter

8th GRADE SCIENCE CLASS

- Scientific Method
- Curse of the PC

8th GRADE SCIENCE

CLASS

Questions / Issues

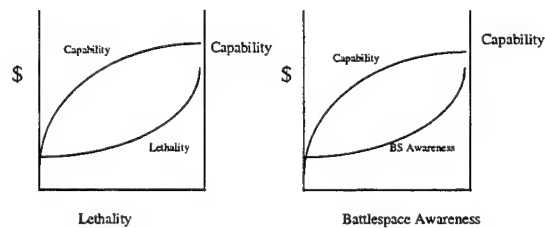
Battle Planning
Wartime Operations
Weapon Procurement
Force Sizing
Human Resource Planning
Logistics Planning
National Policy Analysis

OR Techniques

Simulation
Mathematical Programming
LP, DP, NLP, GP, Network Flow
Game Theory
Probability Theory
Stochastic Processes, Markov Ch.
Statistics / Data Analysis
Data fitting, Regression Analysis
ANOVA, Response Surfaces
Time Series Analyses
Queuing Theory
Decision Analysis
MAUT, AHP, Qualitative

IF IT AIN'T COMBAT, WHAT IS IT?

- Dr. Wilbur Payne
 - Geography lost / gained over time
 - Personnel and equipment lost / killed over time
 - Consumption over time
- Dominant Battlespace Awareness / Knowledge



S-to-T AIN'T ALL...

Strategies



- Neither necessary nor sufficient
- Focus on predetermined solutions
- Crutch
- TMD Example

**** Forces analysts and subject matter experts to THINK LOGICA**

\$64 QUESTION

- Len Sullivan's Chart on Deterrence
- Congressional Language

\$64 QUESTION

Congressional Language - - "the report shall include.."

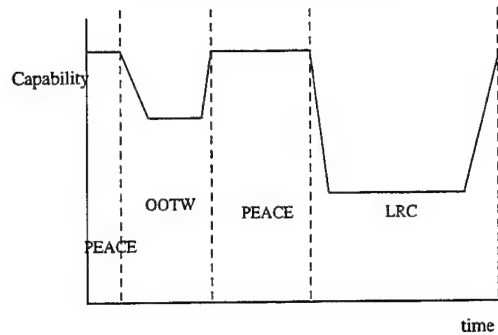
- (1) ... the force structure best suited to implement the strategy
 - - numbers of above the line forces, new orgs, roles and missions....
- (2) The threats examined...and the scenarios developed in the examination...
 - - numbers of specific systems, force units, laydowns, doctrine/tactics, technology...
- (3) The assumptions...cooperation of allies...mission-sharing...risk...warning/duration
 - - probabilities, % forces, flyover rights, % money, multiple sensitivities...
- (4) ...effect on the force structure...peace operations and [MOOTW].
 - - OPTEMPO, robustness, training costs, etc...
- (5) ... effect on the force structure...technologies...precision munitions, stealth, night vision, digitization, and comm...changes in doctrine and ops concepts...
 - - trade space (division vs. cruise missiles), logistics, strategic/tactical lift...
- (6) ...manpower and sustainment policies...support engagement ...more than 120 days
 - - OPTEMPO, readiness, shore rotations, length of assignments, etc.
- (7) ...roles and missions of reserve components...strength, capabilities...equipment
 - - AC/RC mix, unit organizations, acquisition plans, etc...

\$64 QUESTION

Congressional Language - - "the report shall include.."

- (8) ... appropriate ratio of combat forces to support forces...headquarters units...
 - - personnel/personnel, dollars/dollars, units/units, organization changes....
- (9) ...airlift and sealift...to support defense strategic...
 - - closure times of WHAT forces and where, MTM/D, tonnage, risk...
- (10) ...forward presence, pre-positioning...for conflict deterrence and adequate response
 - - tons, units, MPS,days sustainment, ?deterrence, ?adequate response,time, prob...
- (11)extent to which resources must be shifted among two or more theaters...
 - - tons, units, time to respond, swing forces, doctrine, tactics, airlift, sealift...
- (12) ... revisions to the Unified Command Plan...
 - - doctrine, tactics, deployment, warfighting capability/risk, command orgs...

FINAL CHART



- Multiple steps, multiple tools

THE HOLY GRAIL !!

- Focus on Question(s)
- Focus on contributions of Analysis
- Focus on Teamwork / Methodology
- Focus on Final Chart(s)
- Be clever !
 - "Don't be Stupid!" - LtGen Howard Leaf
 - "Just Do It!" - Nike
 - "It Pays to Discover!" - Discover Credit Card

Appendix C1: C4ISR Trade Space

Issue Category Leaders:

John Osterholz, Deputy Director, CISA
Mark Herman, Booz Allen and Hamilton

Participants:

Virginia R. Beall	CNO, N812D
William C. Burch	Applied Military Technologies
Gregg M. Burgess	Cambridge Research Associates
Robert W. Covey	MITRE
Keith T. Dean	OSD/CISA
Lisa Disbrow	The Joint Staff, J8
CAPT Robert W. Eberth, USNR	OPNAV N85X
David S. Eccles	The Aerospace Corporation
James F. Fox	USA TRADOC Analysis Center
W. Dean Free	CNO, N812D
Ray C. Gordon	Los Alamos National Laboratory
Michael G. Hubbell	Frontier Technology, Inc.
Susan M. Iwanski	Northrop Grumman Corporation
MAJ James R. Jeffries	Joint Warfare Analysis Center
Leland T. Joe	RAND
Jerry A. Kotchka	McDonnell Douglas Aerospace
Hyder Lakhani	US Army Research Institute
Richard L. Layton	Evidence Based Research
LtCol Jerry L. Levesque	HQ ACC/XP-SAS
Joseph Mitola III	MITRE
Capt Richard L. Oarr	AFSAA/SAQ
F. Russell Richards	MITRE
Clayton J. Thomas	AFSAA/SAN
LTC Patrick D. Vye	The Joint Staff/J6
Stephen R. Woodall	Teledyne Brown Engineering

C4ISR Team Final Report

GRAM MORS mini-Symposium
1-3 Oct 96

Mission

- Mission: The group is tasked with developing in two days (real time) a study plan for a critical C4ISR question which is to be completed in 2 weeks (not real time).
- Objective: Through a practical application of the mission, discover the key dynamics, drivers, and problems to conducting QRA.
- Question: In support of POM 'XX', what is the most cost effective balance of weapon systems/ platforms and C4ISR capabilities to accomplish the Precision Strike Mission?

C4ISR Working Group Agenda

- Review and modify a 'Strawman approach'
- Break into subgroups to work alternate study plans
- Integrate the pieces into a group study plan (with potential alternates)
- Discuss and write up key process issues imposed on QRA

Strawman Process

- What is the question?
- How much time (2 day, 2 weeks, 2 months)?
- What are the MOEs?
- What is the Approach (techniques, tools)?
- Where is the required data?
- Develop the output?
- Answer the question?

C4ISR Team # 1

Study Plan

MORS Symposium
1-3 Oct 96

Overview

- What is question?
- Define terms/Id Assumptions
- Scope
 - Define the final product
 - Identify key Variables and determine relationships
 - MOE's, MOP's, Risk Variables, Scenarios
- Select Analytical Approach
- Develop Timeline/OPR's

Question

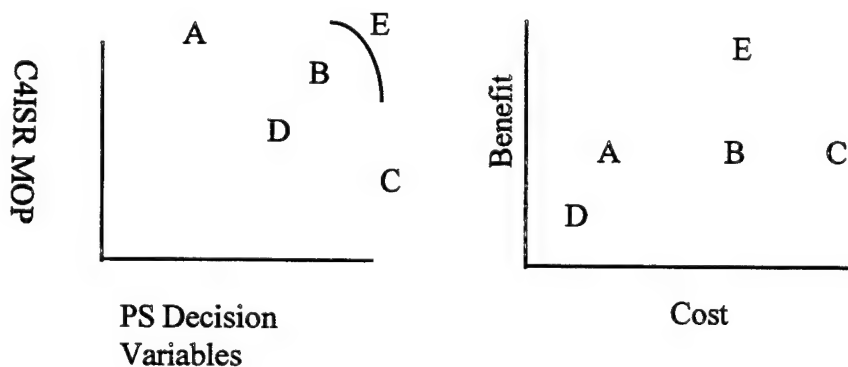
What is most cost effective balance of Weapon Systems/Platforms and C4ISR capabilities to accomplish the Precision Strike Mission?

Corollary Questions:

How can weapon procurement levels be reduced without loss of mission performance by acquiring additional or different C4ISR capabilities?

Are such trade-offs between dissimilar systems cost-effective ?

Final Product

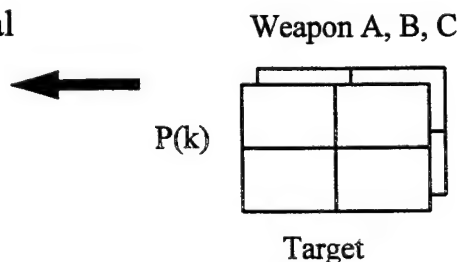


Identifying Key Variables

- Breakout Precision Strike Mission into Target classes/types
- Weigh value of each for mission success
- Identify all relevant weapons and platforms
- Define performance of combinations as a function of C4ISR capabilities (i.e. TLE, BDA, targeting process)
- Assess critical parameters

Identifying Precision Strike Target Classes

- Target Classes
 - Hardened C2
 - Mobile SAMs
 - fixed Industrial
 - C3 Nodes
 - Leadership
 - ...



Relevant Weapons and Platforms

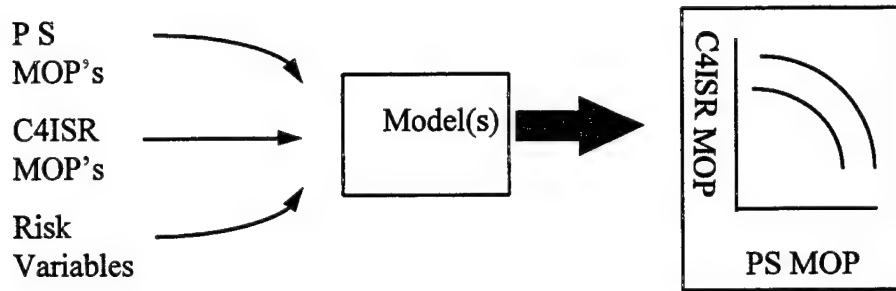
– Weapon A

- Platform 1
 - requirements:
 - $\text{Effectiveness} = f(\text{route plan}) + f(\text{BDA}) + f(\text{Targeting Process}) + f(\text{weapon engineering})$
- Platform 2
 - requirements...
- Platform 3
 - requirements...

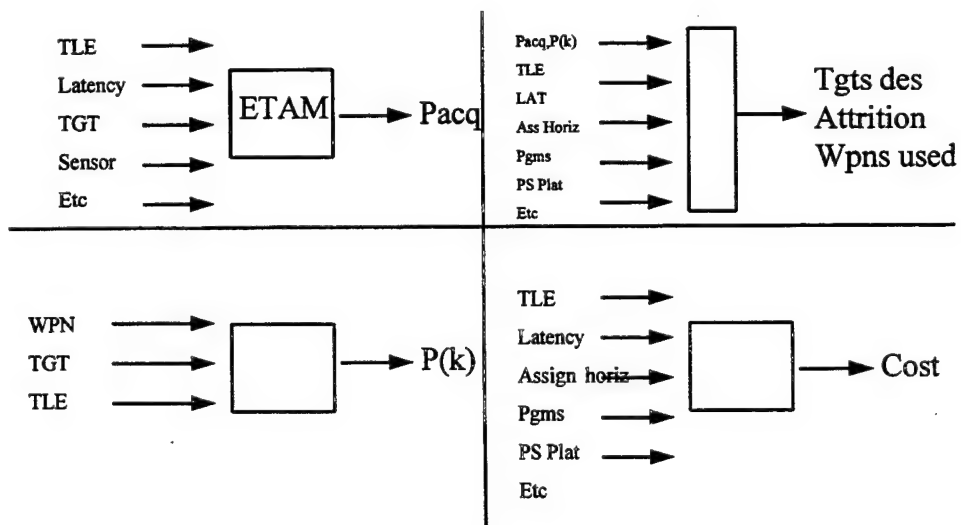
Variables

<u>PS</u>	<u>C4ISR</u>	<u>Risk</u>
• Weapon	• P (BDA)	• Weather
• Aircraft	• Geoaccuracy	• Scenario (RC)
• P(k)	• Data Latency	
• P(Acq)	• C2 Assignment Horizon	

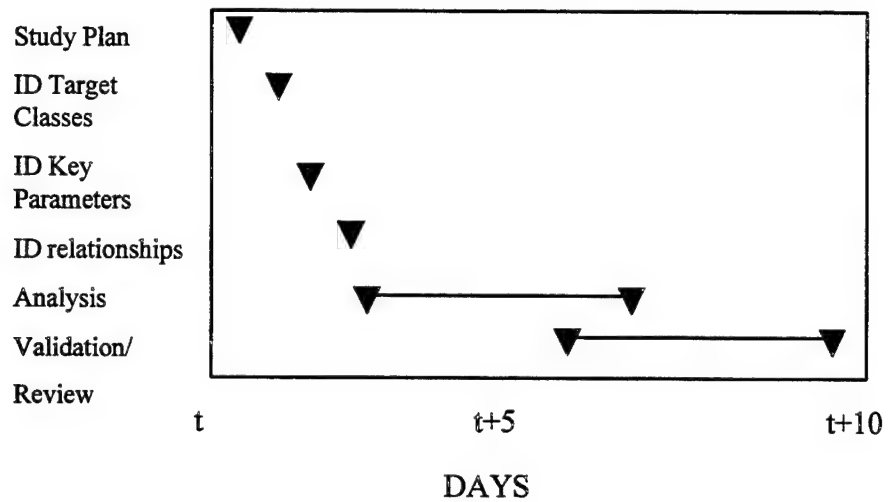
Analytical Approach



Model Functions



Schedule



C4ISR Team # 2 Study Plan

MORS Symposium
1-3 Oct 96

Study Plan

- Problem
- Background
- Objectives
- Key Definitions
- Scope
 - Scenario
 - Theater
 - Forces
 - Excursions
- Essential Elements of Analysis
 - Assumptions
 - Data Sources
 - Methodologies
 - Responsibilities
 - Enclosures
 - EEAs with respective MOEs
 - Problem decomposition
 - Design of Experiments
 - Sample study plans
 - Timelines

Context

- Issues
 - There is a wide range of costs in C4ISR
 - Definition of Precision Strike?
 - Difference between fixed and moving targets
 - Definition of Strike-- air-to-ground, sea to ground, and ground to ground
 - Strike is not CAS, not engaging sea targets
 - Assumes service POMs are done
 - C4ISR definition--sensor platforms, C2 platforms, Battle management platforms

Study Plan

- Problem
 - What is the most effective balance of (precision) weapon systems/platforms and C4ISR capabilities to accomplish the precision strike mission?
- Background
 - DAWMS study
 - CMA
 - Sensor-to-shooter
 - BDA 'quick reaction analysis

Study Plan Cont.

- Objectives
 - Operational: strategic target attack -- fixed and mobile targets
 - ISR in the form of imagery, and real time SIGINT
- Key Definitions
 - Precision Strike
- Scope
 - Scenario
 - Theater- campaign look is needed to generate necessary number of targets
 - Forces
 - Excursions

Study Plan Cont

- Essential Elements of Analysis (EEA)
 - Targets killed per day
 - Munitions per target killed
 - Improvement in munition-target Pk per sensor type
 - Number of times a sensor contributes to targets killed
 - Improvements in BDA
- Assumptions
 - Do not deal with "S&R" in ISR
 - Do not deal with C2 and battle mgt
 - Do not consider effect of environmental variables
- Data Sources
 - NAPA
 - SABSEL

Study Plan Cont

- Methodology #1
 - One primary MOE--targes killed
 - Use 'iso-curves' to compare packages of \$C4ISR and \$weapons
 - Focus on key 'representative' systems
 - Investigate: $Tgt\ Pk = f(Wpns\ CEP, Sorties/day, Sensor\ Probable\ error, Sensor\ A/R)$
 - Use matrix of C4ISR Options - vs- Weapons options
 - Fill in with 'bounding case' of targets killed
 - Condition 'targets killed' based on expert opinion

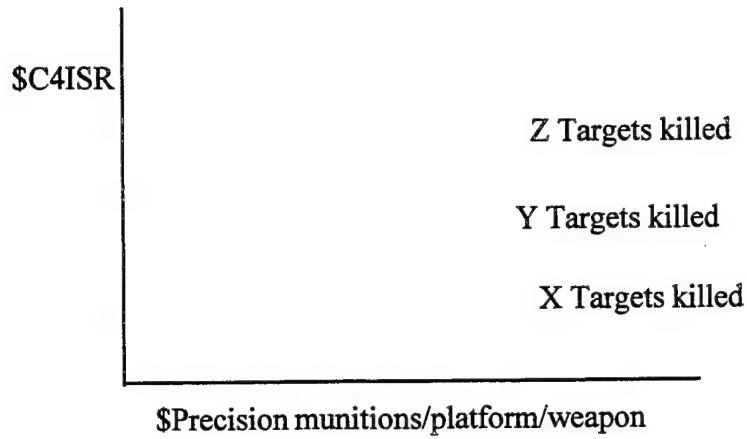
Study Plan Cont

- Methodology #2
 - LOGIT Supply-Demand approach (ID break even point for amount of ISR needed by weapons and targets)
- Methodology #3
 - One primary MOE - Targets Killed
 - Develop a transfer function that relates effect of weapons with platforms, targets, and C4ISR quantity, quality, and timeliness
 - Use NAPA model results to develop prediction equation-
input: user satisfaction; output: cost of C4ISR capability

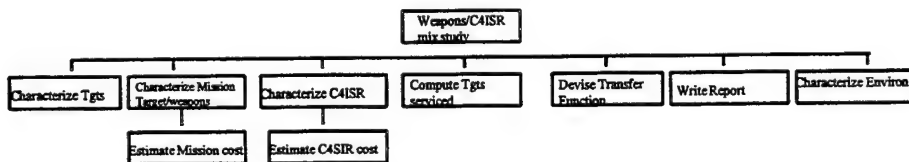
Study Plan Cont

- Responsibilities
- Enclosures
 - EEAs with respective MOEs
 - Problem decomposition
 - Design of experiments
 - Sample study products
 - Timelines

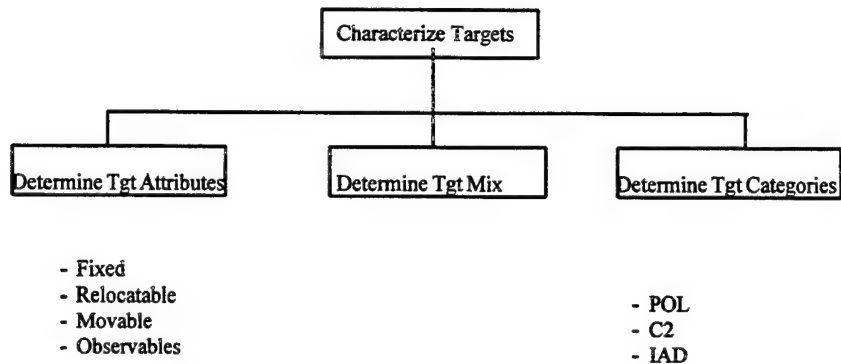
Enclosure: Sample Study Products



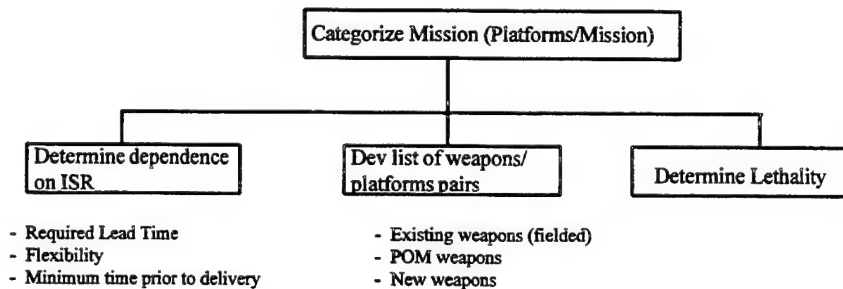
Enclosure: Problem Decomposition



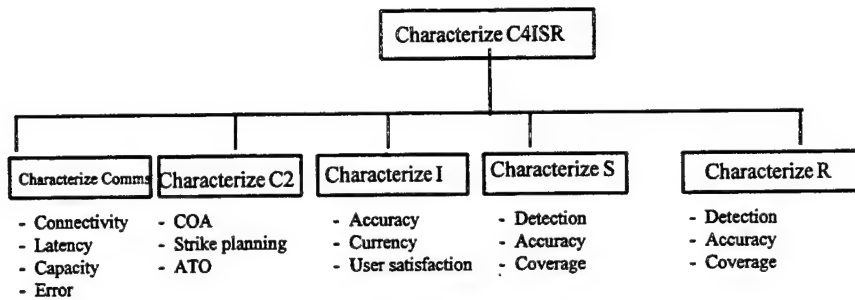
Enclosure: Problem Decomposition Cont



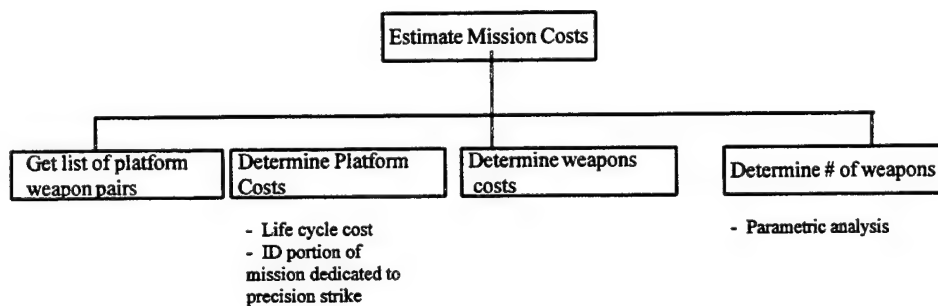
Enclosure: Problem Decomposition Cont



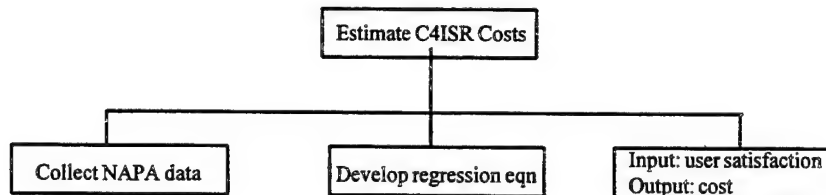
Enclosure: Problem Decomposition Cont



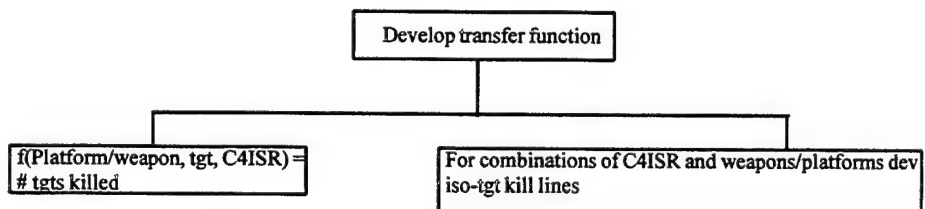
Enclosure: Problem Decomposition Cont



Enclosure: Problem Decomposition Cont



Enclosure: Problem Decomposition Cont



C4ISR Team # 3 Study Plan

MORS Symposium
1-3 Oct 96

Process

- Frame the question
- Establish what resources are available
- What is the context?
- What are the MOEs?
- What is the approach?
- Determine the required data.
- Develop the output
- Answer the questions

Frame the Question

- Who asked the question? Who is the customer?
 - Dr. Kaminski?
- Understand the question?
 - Definition of Precision Strike Mission
- Private or Public study?
- Who else has been asked the question?
 - Sole source or community look
- Who is the audience for the answer?
- What are the results of previous studies?
 - Departure point for this study
 - Approaches, results, acceptance
- Design the output
 - Multi-media, slide show, form and format, final chart
- Socialize the question and the answer
 - Build the constituency

Resources Available

- Time Frame
 - 2 weeks
- Resources/manpower available

Context of the Problem

- Timeframe
 - POM XX for timeframe 20XX
- Terms of reference
- Architectures
 - Physical, functional, technical, information flow
 - POM elements
- Assumptions
 - Technologies
- Scenarios
- Trade Spaces

MOEs

- Equivalent BattleSpace Presence

MOE Development

- C4ISR Enables:
 - More efficient attack
 - More efficient use of forces
 - screening
 - escorts
- Sustained ?

Force Performance



C4ISR

MOE: Equivalent BattleSpace Presence (EBSP)

EBSP = f (area of regard, area of influence, METT-T)
for each unit

METT-T: Mission, Enemy, Terrain, Target, etc

Units:

Air Wings
Battle Groups
MEF
Brigade

MOE: Equivalent BattleSpace

Presence (EBSP)

Area of Regard is a function of:

- Coverage, revisit, timeliness
- % of enemy units detected/identified
- % of friendly units detected/identified
- % of neutrals detected/identified

Area of Influence is a function of:

Ability to react to information, e.g.

- Reallocate resources
- Take risks
- Engage efficiently
- Sustain

Approach

- Initialize the process
- Generate the C4ISR-weapon architecture alternatives (10-15 options)
 - Trade Space
- Collect the required data
- Evaluate and filter
 - Expert opinion
 - Back of the envelope analysis
- Analyze and select promising alternatives (4-6)
 - Expanded tool set
- Build the constituency
- Final presentation

Output

- POM C4ISR capabilities
- C4ISR changes which enable “better unit performance” (BUP)
- C4ISR alternatives that enable BUP vs cost
- Force structure alternatives enabled by BUP with \$
- Risks of proposed solution
 - Technology - will it be there?
 - Reactive threat
 - Different missions
 - Constraining Commander’s options

C4ISR Issue Category Report

Observations

Observations

- Need to begin at the end
 - What does the final product look like
 - Need to narrow, not broaden the question
 - Hypothesis; context of question
 - Socialize answer with Decision Maker
- Not all questions are appropriate for 2 wks; but 1st order answers can focus 2 mon or greater-length efforts
- QRAM is not the traditional process done faster
 - High level MOE(s)
 - Capability, not system oriented
 - Parametric not data specific
 - Need to emphasize fused thinking, can't rely on models

Observations (cont.)

- The more specific the answer needs to be, the less appropriate it may be for QRAM, except with warm (almost hot) base
- Destruction well understood, but flexibility (e.g. C2 assignment horizon) needs to be better understood by Decision Makers, Operators
- Planning requires a focused vision of the effort accomplished by a few individuals who can decompose the issues and task many
- New MOE's/processes likely to run up against the validation barrier
 - Big models, unless in hot status, do not play
 - Data certification
- Risk/Implications of acting on QRAM analysis

Cold vs Warm Base

- Cost near impossible with out warm base
 - requires scenario/system specific data which is antithesis of parametric analysis
 - Cost has a social dimension and takes more time
 - New methods for capability / cost trades required
- Subject matter expertise a big plus
- Specific questions that require precision/detail need a warm base, almost hot base

Process Observations

(Our efforts-cold based vs *warm based efforts*)

- Question framing required great energy vs. *well-defined, well understood question*
- Tendency to jump ahead to apply the process before we define it vs. *well focused group*
- Resources (people) were a problem vs. *having the right people at the right time*
- Incomplete set of experts vs. *experts in doctrine, technology options, previous studies, scenarios, tools*
- Needed to define a new MOE vs. *pre-existing MOE*
- *Some questions will remain unanswered even after the study regardless of cold or warm based efforts*

Appendix C2 – Recapitalization, Modernization, Service Life Extension

Appendix C2: Recapitalization, Modernization, Service Life Extension

Issue Category Leader:

David Graham

IDA

Presenter:

Jack Burton

SPA

Participants:

Terry Colvin
Chris Fossett
Chip Frank
Dean Garrison
Margaret Daly Hayes
Dick Helmuth
Hyder Lakhani
Mary Margret Little
Pat Mckenna
Roxann Oyler
Peter Pandolfini
Rodger Pudwill
Jim Shedden
Ida Smith
Cy Staniec
Daniel Willard

Synergy
GAO
USAF Academy
OAUCSA-SSC
EBR
SAIC
ARI
SPA
USSTRATCOM
JS/J-4
JHU/APL
USA CAA
ASC/XRE
USSOCOM J-7
OSD PA&E
DUSA-OR

Area Definition

The definition of the issue area was discussed at some length within the working group. Three kinds of questions fall within the issue area. These are:

- Tradeoffs between maintaining and upgrading current inventories of hardware versus developing and fielding

a new generation of weapon. A prime example is in tactical aviation modernization. DoD is developing the F-22 and JAST, and the question is when to field these aircraft and whether to extend production of current generation aircraft or extend the life of the existing inventory. Problems like this exist throughout the inventories. For example, one participant related a

parallel issue regarding truck modernization in the Army.

- Tradeoffs in modernization investments across warfare areas. The issues being addressed in the Deep Attack Weapons Mix Study exemplify the kinds of tradeoffs among weapons that are being considered. Along with force structure implications there are modernization implications of these tradeoffs. For example, what kinds of platforms need to be modernized, and what should be the balance of investments between platforms, precision munitions, and C4I capabilities.
- Policies and programs shaping the infrastructure for acquiring weapons. New modernization strategies create demands for flexibility and responsiveness that existing processes and institutions cannot always provide. Hence, as the QDR considers new strategies for modernizing forces it should consider in parallel the acquisition system.

The scope of the area was delineated by the assumption that tradeoffs within this area would be driven by affordability constraints that were derived from higher-level tradeoffs among force structure, modernization, readiness, and sustainability. This assumption was necessary to focus the groups deliberations on inter-generation

investment tradeoffs rather than debating the merits of modernization versus readiness or force structure.

QDR Questions

The group discussed the kinds of modernization questions that could arise in the QDR. We did not assign likelihood to these questions. It seems clear, however, that issues like TACAIR investment, Carrier investments, and platform-munitions-C4I tradeoffs should be central to the debate. As described below, our working groups focused on these areas. In addition, the group identified a number of new (or growing) investment areas, and indicated that consideration should be given to the balance in investment in these areas versus in mainstream hardware. These new areas include biological-weapon defense, counterproliferation, information warfare, and anti-terrorism. The range of modernization issues identified by the group is presented in the accompanying table.

There was discussion of the extent to which the QDR is likely to examine possible radical modernization alternatives, as for example the greatly expanded use of robotics and unmanned vehicles, or the introduction of the arsenal ship or the battle platform. These may be considered by the QDR, but it is unlikely they will be central to the deliberations. Therefore the working groups focused on more mainstream issues.

Modernization Issues that May be Debated by the QDR

INTERGENERATIONAL TRADEOFFS	CROSS-WEAPON AREA TRADEOFFS	POLICIES AND INSTITUTIONS FOR ACQUISITION
<ul style="list-style-type: none"> - TACTICAL AVIATION - Airlift - Helicopters - ARMORED VEHICLES - SSNs, CARRIERS, COMBATANTS - NUCLEAR WARHEADS - LOGISTICS MODERNIZATION - GROWING MISSIONS: COUNTER- BIO DEFENSE 	<ul style="list-style-type: none"> - DEEP ATTACK (arsenal ship) - C4ISR VS. PLATFORMS - BMD VS. CONVENTIONAL FORCES - GROUND VERSUS NAVAL TBMD - UNMANNED VEHICLES 	<ul style="list-style-type: none"> - FLEXIBLE ACQUISITION STRATEGIES (RAPID INSERTION, PROTOTYPING ONLY, ETC.) - ACQUISITION OF JOINT SYSTEMS - ACQUISITION OF COMMERCIAL SYSTEMS (& LEASING) - EVOLUTIONARY ACQUISITION - DEVELOPMENT AND PRODUCTION BASE (CAPABILITY AND EFFICIENCY, AGILITY, DUAL USE) - MISSION PACKAGE ACQUISITION VS PLATFORMS - ROI OF SIMULATION TOOLS FOR ACQUISITION

Background Materials

The examination of modernization issues has been a bread-and-butter activity of the operations research community over the last four decades. Countless systems analyses have been done examining alternative conceptual designs for new systems, and comparing their performance with current systems or upgrades of current systems. Hence the community has a massive base of institutional knowledge, data, and tools to bring to bear on these issues. One of the main challenges facing the community is that the rapid changes in missions, doctrine, tactics, and technologies may have outrun the ability of the analytical tools to fairly assess the contribution of investments. Hence we are at once rich in our ability to assess the "well-structured" modernization problems in those areas where considerable investments have been made over the years by the analytical community, and poor in our ability to assess some of the new "ill-structured" modernization problems posed by the changes in missions, doctrine, tactics, and technologies.

The working group discussion identified several key considerations, which they believe make the job of the analyst different today from what it had been in earlier decades. These include:

- UNCERTAIN MISSIONS -- WHAT PLANNING SCENARIOS FOR MODERNIZATION DECISIONS?
- ADVANCING THREATS -- WHEN WILL CURRENT GENERATION HARDWARE LOSE BATTLEFIELD DOMINANCE?
- FUTURE SYSTEMS NEED TO SUPPORT MANY MISSIONS, PERFORM MULTIPLE ROLES
- COALITION WARFARE WILL ONLY GROW IN IMPORTANCE
- JOINTNESS -- C4ISR DEMANDS TIGHT INTEROPERABILITY; HOW DO WE ACQUIRE NEEDED HARDWARE?
- LOGISTICS PLANNING FACTORS (LIFT REQUIREMENTS) WILL CHANGE AS NEW TECHNOLOGIES ARE FIELDDED

The working group presentations touched on the role of current tools in examining today's questions and on new tools and methods for examining modernization questions. Several team members presented methodologies and "executive-level" tools that should contribute to the systematic structuring of modernization issues. Thanks to improvements in computer power and the effective application of (mostly) commercial software, these analysts are able to summarize large amounts of information, systematically evaluate a wide range of options, and present decision makers with a comprehensible picture of options and measures of effectiveness. The agenda of presentations is as follows:

- Models used for assessing deep attack modernization issues -- Jerry Bracken. This presentation gave a thumbnail sketch of the warfare modeling methodologies, and highlighted the strengths and weaknesses of these alternative models in examining options for performing the deep attack mission. Applying these models raises questions about how to assess the value of deep attack "kills" in these models and how to capture the role of C4I in the deep attack battle. His presentation highlights the challenges facing the analytic community in addressing the new issues being posed today.
- The Army's Value-Added Analysis -- Lt.Col Pudwill. The Army's Value Added Analysis is designed explicitly to examine modernization questions. It considers field effectiveness measures, costs and budget profiles, and production base demands. It displays weapons according to a wide range of measures of effectiveness.

- Design for Experiments -- Lt. Col Shedden. Design for experiments provides a systematic approach for mapping the parameter space, and a framework for maximizing the information yielded by limited numbers of sensitivity runs of a model. The approach improves the ability of the analyst to respond quickly.
- General Campaign Analysis Model -- Mr. Jack Burton. This tool is being used by the Navy for examining joint sea, air, land campaigns, and provides a rapid response method for examining alternative investment strategies.
- Defense Resource Management Model -- David Graham. The Department of Defense is providing this model to Eastern European countries to help them plan forces. It provides an effectiveness scoring system as well as a costing system. It is comprehensive in that it examines the cost and effectiveness of decisions relating to force structure, modernization, readiness and sustainability. The model is not being used for US force planning, but with an investment of several months a data base could be available for examining high-level modernization issues for US forces.

Working Group Assignments

Three working groups were formed, one to address each of the three classes of issues: inter-generation tradeoffs, cross-weapon area tradeoffs, and processes and institutions. Before breaking up, the groups were briefed on their tasking using the analytical "road map" provided by MORS. We borrowed from an approach suggested by the C4I team. The group was asked to suppose they were given a question requiring an answer in days, weeks, or months. Their task was to outline a work

plan for answering the question, and using this as the basis for their report. In addition, a straw man walk through of the methodology was provided, using helicopter modernization as an example. The basic framework asked the group to provide the following:

- Issue Addressed
- Framing of the Issue
- Options and Measures of Effectiveness
- Assessment Plan
 - Conceptual Framework for Relating Options to MOEs
 - Quantitative Assessment Methods (Tools, Data, etc.)

Group 1: Inter-generation Tradeoffs: TACAIR Modernization (Recorder: Lt. Col. Shedden)

This group took as its representative question TACAIR modernization. In framing the issue, the group saw several interrelated sub issues. These include:

- The tradeoff between development and fielding of new aircraft versus modernization of existing aircraft over time.
- The mission requires the US to be able to maintain air superiority, CAS, and BAI over the planning horizon.
- Key to the decision are assumptions about the fielding and proliferation of advanced threats. When will current generation aircraft lose their dominance?
- Two scenarios are relevant for choosing alternatives: The high-threat, two-MRC scenario presents the most taxing threat. The low-threat, MOOTW scenario may create demands for flexibility not required in the high-threat scenario.

Options

Three main options were considered by the group. These are as follows:

- F-22 VS. F-15
- JSF VS. F-16, FA-18, A-6, and AV8-B
- JSF & F-22 versus all

MOEs

A wide range of MOEs were identified. The first group includes operationally driven MOEs, and the second includes some design MOEs that are derived from the operational considerations. The operational MOEs are:

OPERATIONAL MOEs:

- MISSION CAPABILITY (AS, CAS, BAI, PRIMARY SEAD)
- LETHALITY RELATIVE TO THREAT (FLOT MOVEMENT, OPFOR AIRCRAFT KILLED, EXCHANGE RATIOS)
- READINESS (MAINTENANCE, REPAIRS)
- TIME OF FIELDING (WHEN IS FIELDING NEEDED FOR SUPERIORITY)
- SURVIVABILITY RELATIVE TO THREAT (LOSSES PER SORTE)
- SUPPORTABILITY (RELIABILITY, LOGISTICS TAIL & FOOTPRINT, SGR)
- COST (VARIABLE OR CAIV; LIFE CYCLE COST, UNIT FLY AWAY, R&D)
- AFFORDABILITY (FEASIBLE BUDGET FOR PROGRAM)

• DERIVED PERFORMANCE MOEs:

- COMBAT RADIUS
- SUSTAINED Gs
- TURN RADIUS
- WPNS LOAD

Assessment Plan

The first step in the assessment plan is to define the conceptual relationships between the options and the MOEs -- that is how do the options determine MOE outcomes. There are four main areas where assessments are needed:

- Engineering analyses: Relationships between engineering design

alternatives and the derived performance MOEs.

- Combat analyses: Relationships between alternatives and mission performance capabilities, including lethality against forecast threats and

targets and survivability against forecast threats

- Affordability analyses: Relationships between alternatives and forecast program costs. Feasibility of funding program.
- Readiness and support requirements analyses: What are the logistics, maintenance, and support requirements for each alternative.

The next step in the assessment plan is to identify ways to make the quantitative assessments for these relationships. The group focused primarily on combat assessments, although there would be parallel considerations in each of the other dimensions. They found there is a range of available tools for assessing the combat performance of alternative designs. These include:

- THUNDER*
- TACAIR*
- SUPPRESSOR*
- OME
- EADSIM

The group noted that the models indicated with an asterisk would require six months of data preparation in order to address new systems or scenarios. Hence these models would not be available for rapid response analyses unless there was a warm data base already in hand.

Group 2: Cross-Weapon Area Tradeoffs: Deep Strike (Recorder: Lt. Col. Pudwill)

Deep strike was raised as an issue by the Roles and Missions Commission and currently is the subject of a major Defense Department study. Hence, this issue is likely to be at the center of the QDR's deliberations. From an analytical standpoint, this issue raises a complex set of

investment tradeoffs for next generation platforms (air, land, and sea), precision munitions, and C4I capabilities. There are important considerations regarding the nature of threats and the kinds of scenarios that will demand deep strike capability.

•MOEs

Deep strike capability is intended to serve many missions. The primary mission is to provide an initial defense against massed armored invasions and to support an offensive counterstrike. Another key mission is the ability to attack mobile weapons of mass destruction, such as the SCUD launcher, providing defense for forces in theater and neighboring civilian population. Precision deep strike may also be used to backup peacekeeping operations (as in Bosnia) or to retaliate against violations of sanctions (as in Iraq).

MOEs will vary somewhat across these scenarios, but the main factors in all cases include:

- Timeliness of strike
- Precision and lethality against intended targets
- Ability to mass force against massed forces
- Collateral damage & unintended casualties
- Vulnerability of friendly forces to casualties
- Relative costs

Assessment Plan

The group focused on alternative assessment options available within days, weeks, or months. In this area, as probably in all others, there are many tools that can readily be applied to questions such as these if the advance preparation had been made in building the needed data bases. At the same time, the group believed the most of the

kinds of modernization questions the QDR will address will likely have been the subject

of recent analysis, and so a warm base is probably available somewhere.

Assessment Approaches Versus Time to Respond

	DAYS	WEEKS	MONTHS
COLD BASE	DELPHI METHODS EXPERT OPINION	"META STUDY" – REVIEW LITERATURE AND DRAW ANALOGIES	SOME FORMAL ASSESSMENTS POSSIBLE; DATA IS THE LIMITING FACTOR
WARM BASE	A FEW CASES COULD BE EXAMINED IF AVAILABLE DATA & MODELS ARE SUITABLE	SENSITIVITY ANALYSIS POSSIBLE, EVEN WITH DETAILED MODELS	TOOLS AND DATA COULD BE MODIFIED AND TAILORED TO ADDRESS NEW ISSUES

Group 3: Processes and Institutions for Modernization: Flexible Acquisition Strategy

(Recorder: Dr. Willard)

DoD is making significant strides in improving its acquisition process, but the continued march of technology and the strategy for modernization will require continuing adaptation of DoD's acquisition processes and institutions. Because infrastructure issues may be important in the QDR's deliberations, some consideration may be given to such issues. Essentially the issues to be analyzed are the relative costs and benefits of adopting alternative management processes or restructuring the institutions for modernization. The group saw several questions of potential relevance. These include developing the institutional

framework needed to implement the kinds of C4 programs envisioned in Joint Vision 2010 and to manage the procurement and use of commercial technologies. The question selected for analysis by the group is whether DoD should modify its acquisition processes to manage the time programs spend in development so that fielding dates are optimized relative to threats and budget considerations. This approach has been called a "flexible acquisition strategy."

The issue can be framed by the question: Should DoD put in place mechanisms to manage the timing of next generation weapons? The question is motivated by three considerations: (1) Affordability constraints preclude developing a new generation of weapons across the board. If DoD tried to pursue programs in all areas, the budget would be spread so thin that little progress could be made on any front. (2)

National strategy requires that US weapons must continue to dominate, so our fielding of next-generation weapons in any area must be timed to beat the emerging competition. And (3) the way to reconcile these considerations is to develop processes and institutions capable of selectively managing the time phasing of programs.

Options

The basic options illustrate the nature of the strategic alternatives. In a given program area, there are three options. The three options are:

- Continuous inter-generation overlap in development and production
- Allow gaps in development and production
- "Churn" programs in DEMVAL or EMD. Churning programs in DEMVAL would entail commissioning a series of subsystem-level prototypes. These would develop and mature technologies and explore manufacturing issues. In such a program, DoD would be many years away from being able to field a next-generation system. Churning programs in EMD would entail commissioning a series of full-system prototypes. These would develop and mature technologies, pursue system integration issues, and develop manufacturing approaches. In such a program, DoD would be a few years away from initiating production.

The integration of these options across all program areas would constitute a flexible acquisition strategy. In each warfare area, the time required to field a next-generation weapon would be managed so that the nation would be assured the US could field the weapon earlier than any adversary. This could be an effective strategy if there are

areas where DoD can postpone fielding new systems, focusing on the early fielding of systems where modernization needs are greatest, while still maintaining its ability to field weapons in all areas when the need arises.

MOEs

The MOEs identified by the group for evaluating the flexible acquisition strategy relative to the current acquisition strategy are listed below.

- Cost And Affordability
- Battlefield Dominance
- Confidence In Strategic Warning
- Time To Field (Earlier Than Threats?)
- Technological Dominance
- Production Capability (Ramp Up)
- Jobs (Political Implications)

Analysis Plan

There are significant number of conceptual relationships between the strategy options and the MOEs outlined about. These are as follows:

- Support For Defense Program
- Options Will Shape Costs In Weapon Area Over Planning Horizon
- Time To Field A New Capability; Estimates Draw On Past Experience
- Battlefield Dominance Assessed Using Conventional Combat Lethality And Survivability Tools And Data & Estimates Of Threat Over Time
- Production Capability And Ramp Up Based On Business Base Forecasts, Business Decision making, And Industrial Engineering Assessments

These options raise questions that have been studied in many contexts. However, most studies have focused on specific programs and industries (e.g. the strategy for main battle tanks and the US tank

production base, or the strategy for submarines, etc.) Because of the variety of issues, and the specialized program and production-base circumstances, it is likely that any future analyses will require case studies as well.

What is different in the flexible acquisition strategy is to tier above these individual sector studies an overall framework for managing the Defense-wide pace of modernization to meet national security objectives. Some of the executive decision tools outlined above would be helpful in assessing this option.

Observations and Recommendations

Because the analysis of modernization issues has been an important activity of the analytical community, we are probably in better shape here to address the questions of the QDR than in many of the other issue areas. Nevertheless, changes in strategy, missions, doctrine, threats, and technology all introduce wrinkles that complicate the application of traditional tools, and may invalidate their use. In particular, the deep attack modernization issue poses many questions that traditional combat models were not designed to analyze. Issues with respect to processes and institutions similarly pose a new set of questions.

Our general assessment is that where traditional modernization questions are being asked there is a good chance the community will be able to respond with analytical tools and data. Even the large-scale models can provide responsive turnaround when they have the appropriate scenarios and data bases prepared in advance. The group believes these models are prepared to handle the bulk of the modernization questions likely to be raised by the QDR.

Our recommendations to the sponsors would be as follows:

- Develop a rapid straw man analytical plan for the QDR. To do this, conduct an early triage analysis of potential modernization questions. Which questions are (a) important (for security or budgetary reasons), (b) likely to turn on empirical questions or analysis, *and* (c) amenable to analysis given the current inventory of tools and data. Scope out the areas to be assessed in depth -- centerpiece areas for the QDR. As noted above we believe these will include TACAIR modernization, Carrier modernization, and deep attack.
- Quickly energize the analytical community to gear up for the issues that will be assessed.
- Identify areas where tools and data aren't available, where analysis is not sufficiently mature to contribute significantly to the debate, or where the question is likely to turn on other considerations and plan on how to address these through other means in the QDR.
- Consider process and institutional issues as well as the end product issues of force structure, modernization, readiness, and sustainability.

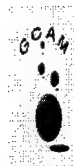


GENERAL CAMPAIGN ANALYSIS MODEL DEMONSTRATION

1 OCTOBER
1996

ASSESSMENT
DIVISION
(N81)

spa



GENERAL CAMPAIGN ANALYSIS MODEL (GCAM)

- STARTED DEVELOPMENT OCTOBER 1995
- OBJECT ORIENTED MODELING ENVIRONMENT
- TOOL SET FOR THE MILITARY ANALYST
 - HIGH LEVEL MODELING LANGUAGE
 - ANALYST WORKING ENVIRONMENT
 - C++ MONTE CARLO SIMULATION ENGINE
 - CONFIGURATION CONTROL MANAGER
- INTEGRATES MODELING FOR ASSESSMENTS
- APPLICATIONS FROM JOINT CAMPAIGN TO ENGAGEMENT LEVEL



GCAM DEVELOPMENT GOALS

- RESPONSIVE TO DEMANDS OF POM ASSESSMENTS
 - QUICK-TURNAROUND
 - INTERFACE WITH OTHER MODELS
 - INTEGRATE MODEL AND STUDY RESULTS
 - SUPPORT TRADEOFF ANALYSIS
 - SHOW IMPACT OF EXCURSIONS ON HIGH-LEVEL MOEs
 - HIGH-QUALITY PRODUCT TRANSPARENT TO DECISION-MAKER
- DIRECT ANALYST CONTROL OF APPLICATION DEVELOPMENT
 - LEVERAGE ANALYSIS TEAM'S EXPERIENCE
 - C++ PROGRAMMING EXPERIENCE NOT REQUIRED

14M DOWNS.PPT:
11/19/96
EW/POMER/GCAM-2



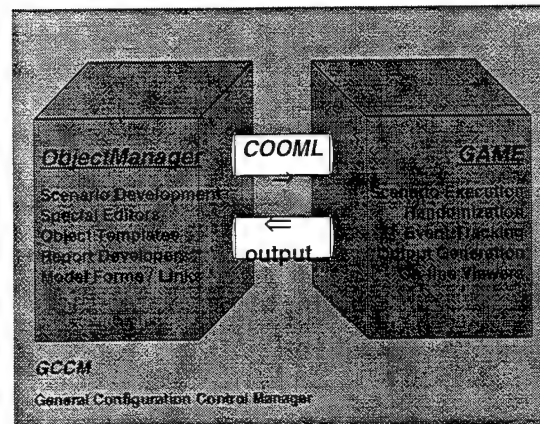
GCAM MODELING ENVIRONMENT

- ANALYST DEFINES
 - SET OF UNIT OBJECTS
 - OPERATIONAL PHASES FOR UNIT OBJECTS
 - RULES CONTROLLING TRANSITIONS BETWEEN OPERATIONAL PHASES
- MODELING ENVIRONMENT INCLUDES
 - MAP-BASED MOVEMENT
 - UNIT-DEPENDENT BATTLE SPACE PERCEPTION
 - REPORTING AND COMMAND CHAINS
 - CONDITIONAL UNIT ORDERS
 - INVENTORY TRACKING AND CONTROL (LOGISTICS)
 - DAMAGE AND ATTRITION
- ANALYST SELECTS ENVIRONMENT FEATURES USED AND LEVEL OF DETAIL FOR SPECIFIC CASE

14M DOWNS.PPT:
11/19/96
EW/POMER/GCAM-4

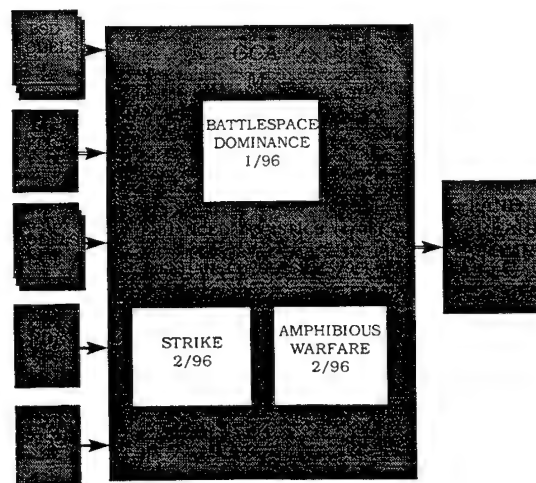


GCAM APPLICATION SUITE



134L (204) PPT-
11/12/96
DD/PC/WS/SC/AFM-1

FY96 GCAM DEVELOPMENT





CURRENT APPLICATIONS

- CAMPAIGN ASSESSMENTS FOR DON PR-99
- MRC-WEST SCENARIO DEVELOPMENT AND CAMPAIGN ANALYSIS
- LRC(SLOC)/MRC-EAST SCENARIO BASELINE WARM
- JMA, IBR, AND QDR ISSUE ANALYSES

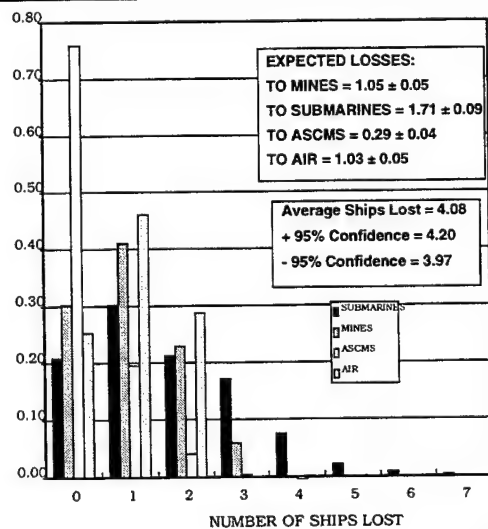
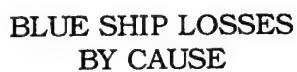
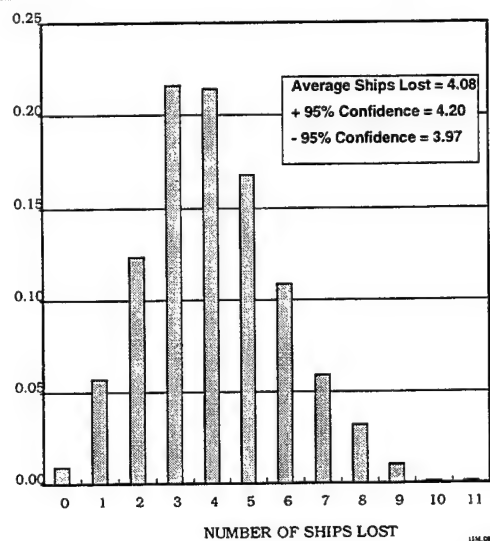
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DR/POWER/CEAS-7



MODERNIZATION ANALYSIS APPROACH

- IDENTIFY QDR ISSUE
- CONDUCT COST AND EFFECTIVENESS ANALYSIS OF MODERNIZATION OPTIONS (UNIT AND/OR MISSION LEVELS)
- IDENTIFY MOEs AND RISK TOLERANCE
- SELECT BASELINE(S) CAMPAIGN (LRC(SLOC)/MRC-EAST OR MRC-WEST)
- MODIFY BASELINE(S) (IF NECESSARY)
- ADD EACH MODERNIZATION OPTION TO BASELINE(S)
- SHOW VALUE ADDED FOR EACH OPTION TO BASELINE(S)
- RANK OPTIONS BASED ON EFFECTIVENESS AND COST-EFFECTIVENESS

114L DR001/PP1
11/18/98
DR/POWER/CEAS-8



Appendix C3: Readiness/Sustainability/Supportability

Issue Category Leaders:

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ODUSD(R)RP&A
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Participants:

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Kent D. Lambert
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Michael A. Parmentier
LCDR Glenn C. Robillard
MAJ James H. Taylor
David W. Thompson
COL Bobby J. Thornburg

AFSAA/SAGW
Naval Center for Cost Analysis
OSD (PA&E)
RAND
The Joint Staff, J4
Evidence Based Research
AFSAA/SAZ
The Joint Staff, J8
Foxhall Group
US Army Space & Strategic Defense
Command
OCSA-PAED
AFSAA/SAQ
DMDC
NAIC/GTI
ODUSD (Readiness)
Naval Inventory Control Point
AFSAA/SAQ
Naval Inventory Control Point
DACS-ZC-SSC

This section will be forwarded separately.

Appendix C4 – Military Operations Other Than War

Appendix C4: Military Operations Other Than War

Issue Category Leader:

RADM Gary Wheatley, USN (Ret)

Evidence Based Research

Presenter:

Dr. Richard Hayes

Evidence Based Research

Participants:

Mr. Paul Bloch
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Ms. Sharon Pickup
Mr. Royce Kneece
Maj Russ Hodgkins
Mr. Gary Horne
Dr. Dean Hartley
LTC Greg Parlier
Mr. Tom Iten
Dr. Alfred Brandstein
Col Tom Allen
Ms. Karen Somers

Naval Postgraduate School
SETA
US Army SSDC
Congressional Budget Office
Office, DUSA(OR)
AF Studies & Analysis Agency
US General Accounting Office
OSD (DPA&E)
AF Studies & Analysis Agency
MCCDC CNA Representative
Oak Ridge National Laboratory
ODSA-PAE-RPAD
Raytheon E-5 Systems
MCCDC
AF Studies & Analysis Agency
HQ ACC/XPSAS

C4.1.0 Introduction

Tasking for the QDR specifically includes OOTW for the first time. The requirement states: (report on) "The effect on the force structure of preparations for and participation in peace operations and military operations other than war (MOOTW)." Accordingly our team first sought to frame the issues and develop a vision of the way one could define and analyze OOTW. The team developed several relevant assertions as a starting point:

- OOTW is not new. The U.S. military has performed OOTW since its inception.
- The Cold War produced an unusual and perhaps artificial period of stability for approximately 40 years (1950-1990).
- Post Cold War instability has spawned numerous OOTW opportunities.
- OOTW appears to be a growth industry.
- OOTW is consistent with the U.S. National Security Strategy of "Engagement and Enlargement."
- "Warm Base" analytical QRA tools do not presently exist primarily because the required historical data and data bases on

OOTW do not exist in a workable form (i.e., apples and oranges, depending on the data source).

- “Cold Base” analyses are possible within the QRAM Assessment Chart two-day, two-week, and two-month time frames, and are described within the report.

C4.1.1 Themes

The team focused its analyses on four specific themes:

- Better tools for planning and analysis of OOTW
- MOEs
- Impact on force structure
- Training and perstempo impacts

C4.2.0 General Approach and Methodology Required for OOTW QRA

1. The team first determined that a historical OOTW data base was required. While there appears to be ample data on OOTW developed over the past 5-6 years, it is in different formats and not centralized in one location or under one executive agent. If the data is consolidated and harmonized, trend analysis can determine near future requirements and forecasting methodologies can be used to look at more distant futures.
2. Look for commonality in force structure across OOTWs.
 - There may be significant differences between OOTW before and after fall of Berlin wall.
 - Examine possible differences in uses of U.S. forces and services after 1990.
3. Predict requirements based on multiple possible scenarios.
 - Need to assess risk in other areas (MRC) when assets are devoted to OOTW.

- Decide upon a reasonable mix of OOTW scenarios and analyze requirements for each (develop a matrix). Measures of robustness should be developed.
- Possibly use Universal Joint Task List (UJTL) and current MRC force requirements to determine areas of congruence between OOTW and warfighting.

4. Develop a list of unique assets needed for various OOTW in terms of people (specialties), units and equipment (e.g., military police, communications specialists, civil engineers, sensor platforms, etc.).
5. Consider contribution capability of allies, likely coalition partners and contractors (e.g., Brown and Root).
6. Look at technologies that can alter demand for force structure (e.g., trade off between remote sensor and on-the-scene soldier).
7. Look at dual-use technologies (e.g., mine clearing capability useful for both OOTW and warfighting).

C4.2.1 Data Needed for Analyses and Partial Listing of Sources

Data required for OOTW analyses includes (inter alia) normalized data on OOTW missions, forces deployed, duration, lessons learned, outcome and reasons for completion or termination.

Partial List of Sources:

- MITRE (Study currently being updated)
- SOUTHCOM
- SOCOM

- CNA database being developed by Adam Segal; covers Navy and Marine OOTW.
- RAND: Jim Quinlivan.
- AFSAA—Air Force “Stressed Systems” study (perstempo/optempo data and MOEs).
- Army has database containing costs of OOTW deployments (SAFM-BUC-E). (See Attached Point Paper. (Attachment 2))
- Navy data on perstempo and SSBN deployment experience (Blue/Gold manning).
- CINCs’ Lessons Learned libraries.
- National Guard database.
- Service Historian records and reports.
- Joint Staff database developed for Lou Finch (Maren Leed, RAND)
- ARI Report on OOTW History (Dr. Bob Holz).

C.4.2.2 Measures of Effectiveness and Force Readiness Issues

1. To develop meaningful MOE, it is first necessary to address the boundaries issue; that is, OOTW vary widely in purpose and mission and a measure of effectiveness or success may not be the same in every case. For example:
 - OOTW for military purposes (Libyan strike, push back Saddam, etc.).
 - Law enforcement (Drug interdiction support).
 - Humanitarian support (disaster relief, refugees).
 - Peace Keeping, Peace Enforcement (Sinai, Bosnia).
 - The UK is developing “Normalcy Indicators” in Bosnia. We should follow this development to see if these indicators are of practical use.

2. There is a need to develop multi-dimensional measures of readiness.
 - Data exists at some unit levels in different services (e.g., USAF SORTS data). Also USACOM is developing a model that attempts to show component readiness impact on overall unit readiness.
 - Chairman JCS gets report on overall readiness monthly however there are concerns that these reports tend to be inflated and contain some inaccuracies. Both the Air Force and Army team members stated that the AFSAA and ACC have found errors and reporting differences in Perstempo and TDY rate data. Data are not necessarily standardized.
 - Another problem recognized was that current “C-Rating” or percent fill do not capture OOTW capabilities (e.g., the unit could be C4 for combat, but C1 for Law Enforcement).
3. Other factors to consider:
 - Need to analyze trade offs between use of military or contracting for various OOTW.
 - Serious consideration of anticipated mission time factors is needed. Will deployed units be available in time for other contingencies if needed?
 - Need to measure impact on total force (not just the units on OOTW) and ability to respond to LRC/MRC if one arises (hollow force?).

C4.2.3 OOTW Analyses Tools (Available and Required)

1. OOTW analyses can be performed with several existing tools once a normalized database is assembled. The following are examples:
 - Spreadsheets

- Influence Diagrams
 - Markov chain diagrams and processes
 - Probability theory
 - Statistical analysis
 - U.S. Army TRADOC/TRAC CAPS OOTW model presently under development reportedly yields force structure required for OOTW deployments.
 - SOUTHCOM/SYNECTICS developing a model (DEXES/CAM) which is used for training for instability and civil affairs.
 - SPECTRUM reported as having a high resolution model for LIC/LRC under development at Fort Leavenworth.
 - "Panther" model reported being used by SOUTHCOM, School of the Americas, NSC as a seminar driver. Also being developed by Fort Leavenworth.
 - Disaster planning model "Plowshare."
 - UK reported using systems dynamics tools (flows).
 - CAA working with the CINCs to do TAA (Warfighter in-the-loop analysis).
 - Trade off tools such as "Expert Choice," and QFD (Qualitative Functional Deployment).
2. Realizing that OOTW analyses are new to the QDR (and that we definitely have a cold base for any current analyses), we need to begin now to develop and assemble data and tools for the next QDR. Some of the things needed are:
- Normalized database
 - Taxonomy of OOTW missions
 - A "basket" of scenarios
 - An OOTW analysis model.

C4.2.4 Training Issues Requiring Analysis

1. Many of the skills required for OOTW are not the normal "soldier" skills, or

perhaps exist only in specialized units such as Military Police, Port Handling Teams and so on. An Infantry soldier cannot satisfactorily perform police duties without extra training. If, in the words of General Hamilton, we are to have "transformers" (soldiers who can adapt quickly to a variety of different missions), we need to analyze ways to train and equip for adaptability.

2. A team member reported that during preparation for Task Force Eagle (IFOR), the Army conducted high tempo, specialized training at the Europe Combat Maneuver Training Center (CMTC). This experience should be captured and analyzed.
3. CNA is reported to have a publication that lists the skills and training needed for peacekeeping missions. This type of task analysis should be expanded to analyze each skill and training requirement for the full spectrum of OOTW.
4. A further analysis of how technology can improve or eliminate training is needed (e.g., automatic language translators could eliminate or reduce the need for the foreign language training that is needed for many OOTW).
5. OOTW training requirements may cause second order effects such as requiring more instructors, or perhaps even more end strength (because soldiers in a longer training pipeline are not available for other duties), and this could have a possible impact on force structure.

C4.3.0 Conclusions

1. The QDR specifically tasks reporting on the effects of OOTW on force structure.

Analyses will assuredly be required. At present there is no single agency identified to build an integrated database for OOTW.

2. OOTW missions and scenarios vary widely and OOTW is expected to be a growth industry. U.S. armed forces can expect to be actively engaged in OOTW throughout the period of the QDR and beyond.
3. OOTW have impacts on readiness and perstempo; their significance and impact on force structure have yet to be fully analyzed.

4. Multi-dimensional readiness indicators are required to determine both the ability to conduct various OOTW, and the combat readiness of units deployed on OOTW to perform their primary combat roles.
5. Certain military capabilities required for OOTW (and combat operations) are in limited supply (e.g., USAF ALCE units), may be heavily reserve force dependent, and can become the "short poles" that limit OOTW capability and/or response time.
6. The following chart presents the team's assessment of QRA options:

TIME FOR QRA	2 DAYS	2 WEEKS	2 MONTHS
WARM BASE	NONE	NONE	NONE
COLD BASE	Conference call to former OOTW commanders and other experts.	Ad-hoc seminar of OOTW experts.	Tiger team to integrate and analyze various databases.

Figure C4.1 QRAM Assessment Chart

C4.4.0 Recommendations

1. Assign an executive agent for OOTW analyses. Within the Joint Staff, J-8 would appear the likely choice.
2. Integrate and normalize the various OOTW data and databases so that meaningful analyses can be performed. Conduct analyses using traditional tools and models. Develop new models if appropriate. This is essential to provide a warm base for QRA, and could be

conducted in-house or contracted out. The experiences and data from allies and coalition partners should be included.

3. Develop multi-dimensional readiness measures to include OOTW missions and the impact of these on LRC/MRC capability as well as the total force.
4. Analyze the impact of OOTW on perstempo to include sub-units or highly specialized units whose data may be

subsumed within larger categories.
Identify the “short poles.”

5. Analyze the contributions and impact that technology can have on OOTW.



Joint Warfighting into the Twenty-First Century: Where We Have Been and Where We Are Going



Threats to Security by Means Other Than War

presented by

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Source: *State of the World Atlas*, 1995 and *The CIA Factbook*, 1996



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States' Main Role In Global Illicit Drug Network



■ Drug Producer

■ Conduit for Drugs, Drug Money and/or Processor Chemicals

Source: *State of the World Atlas*, 1995 and *The CIA Factbook*, 1996

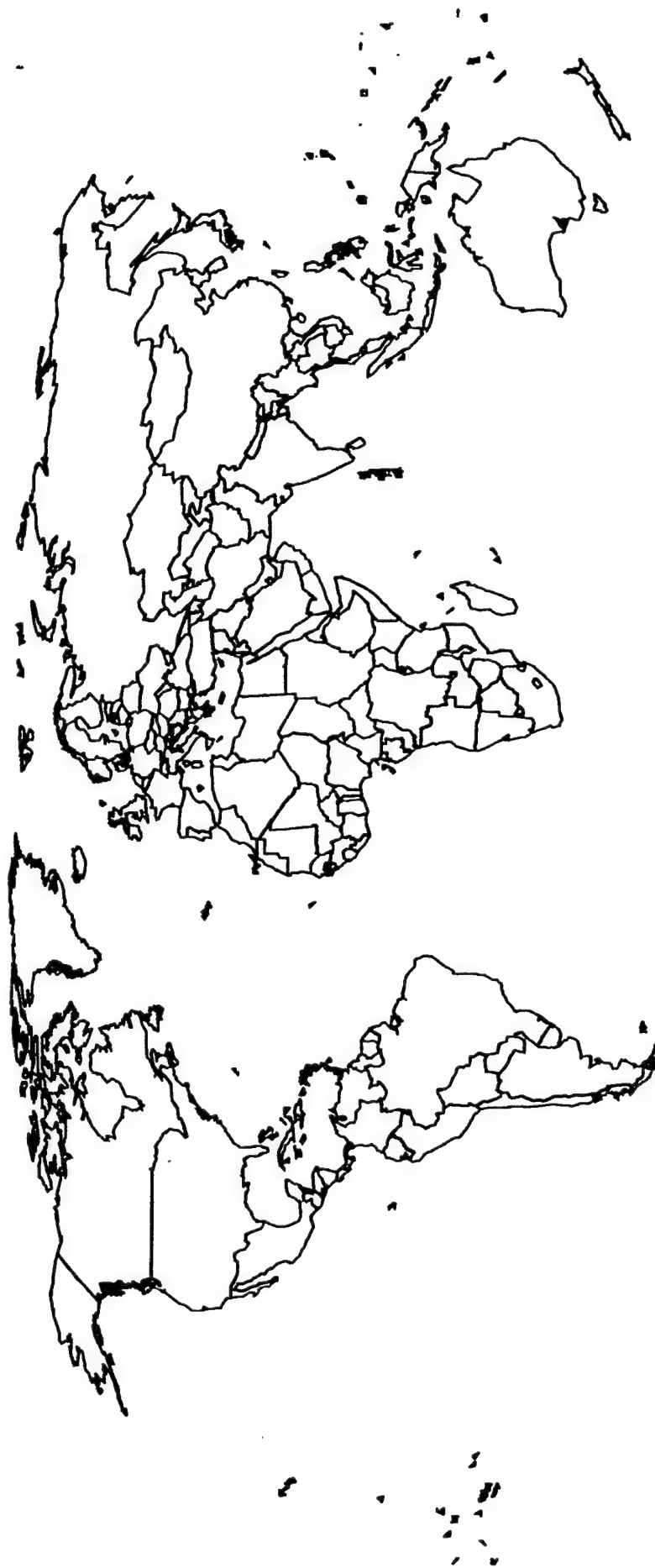


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Major World Peacekeeping Operations 1992-1996



Adapted from *Strategic Assessment 1995: U.S. Security Challenges in Transition and Strategic Assessment 1996: Instruments of U. S. Power*, Institute for National Strategic Studies, National Defense University

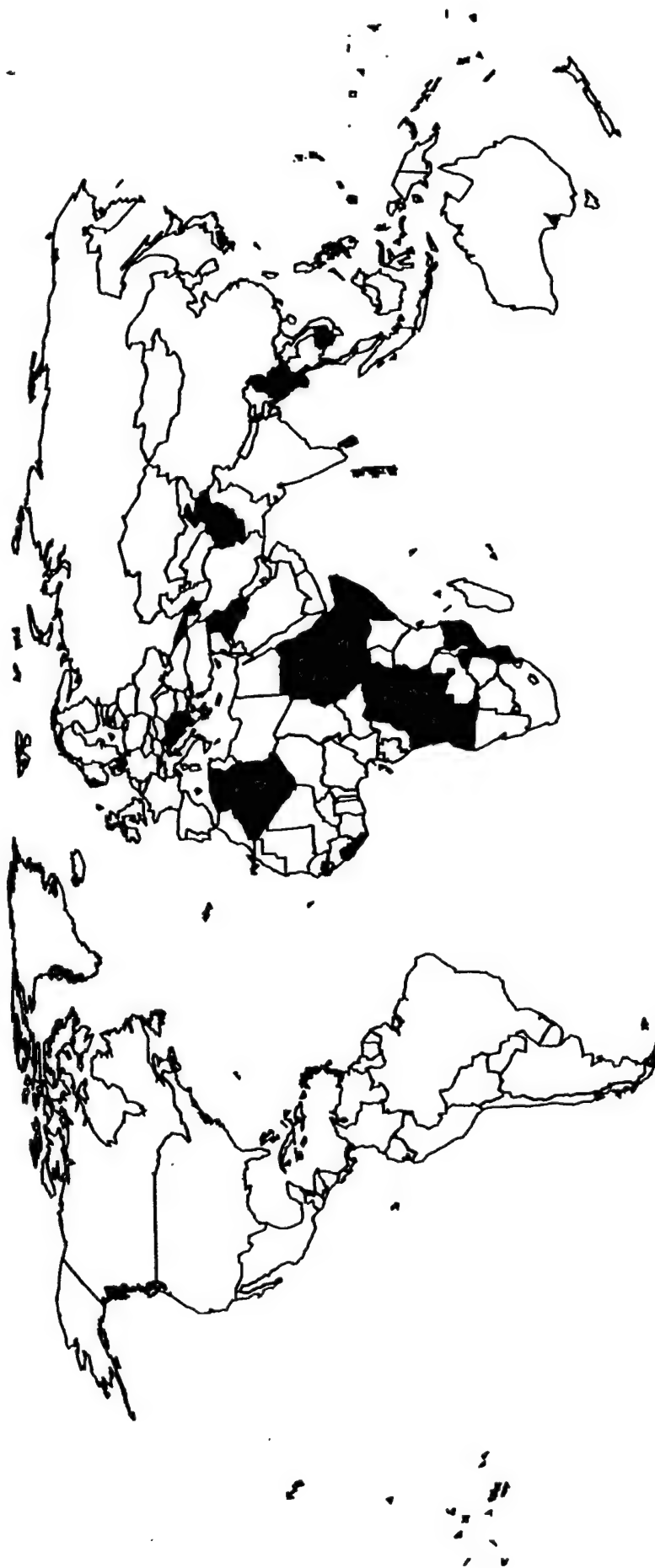


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Humanitarian Emergencies 1992-1996



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U. S. National Security Interests



- Deter, prevent and defeat attacks on U. S. territory and citizens
- Prevent catastrophic collapse or disruption of global systems: trade, financial, energy and environment
- Prevent the emergence of a hostile or disruptive hegemon
 - In key regions
 - On the seas
- Promote democratic systems and free markets as a means for ensuring global, regional, and strategic country stability
- Protect allies, friendly governments and strategic states

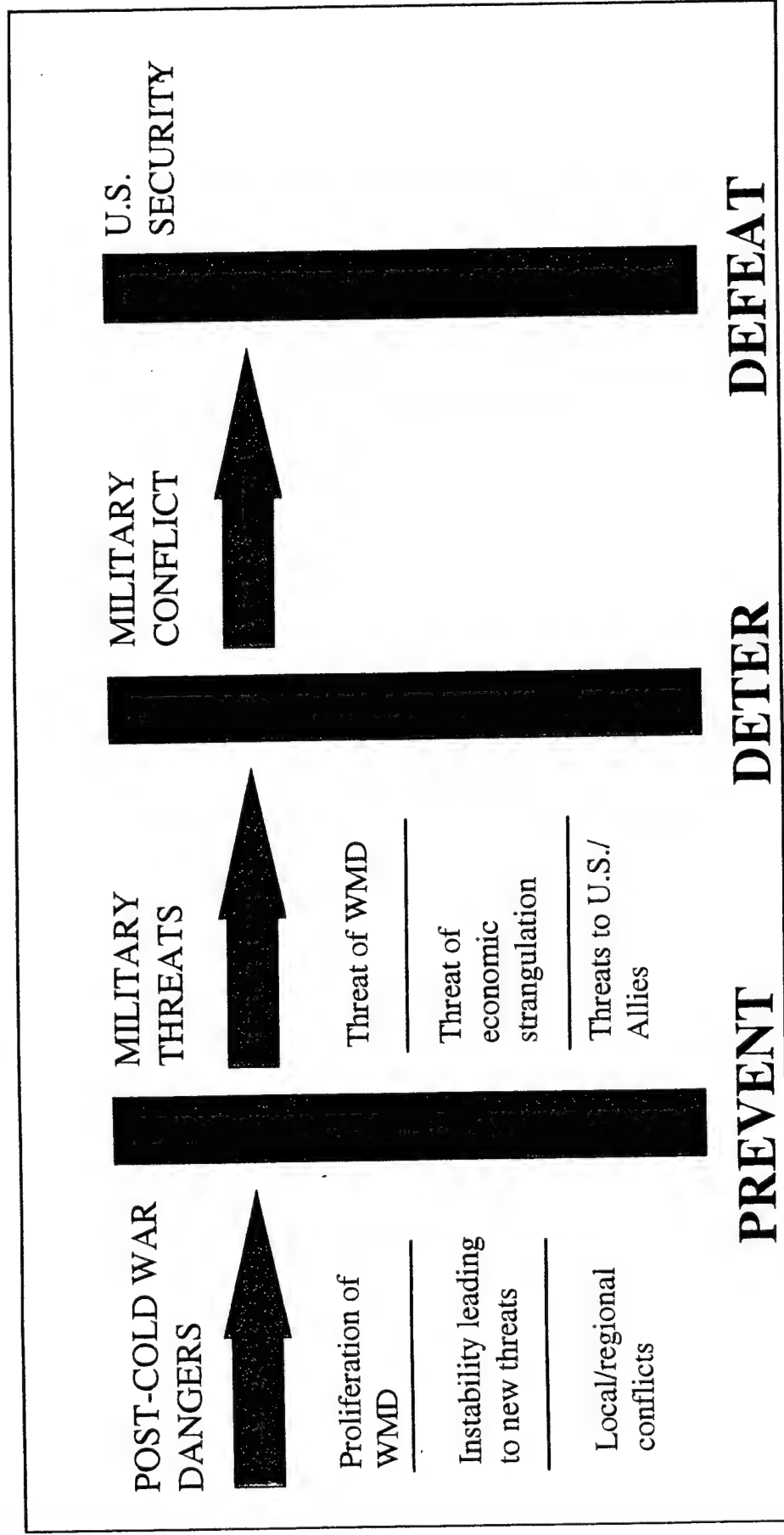


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The Three Lines of Defense



Adapted from Perry, Defense 96, Issue 3, p. 5.



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Insights From OOTW Experience



- Actors are:
 - Multiplying
 - Diversifying
 - Miniaturizing
 - Becoming More Mobile
- The Threat is Increasingly Ambiguous

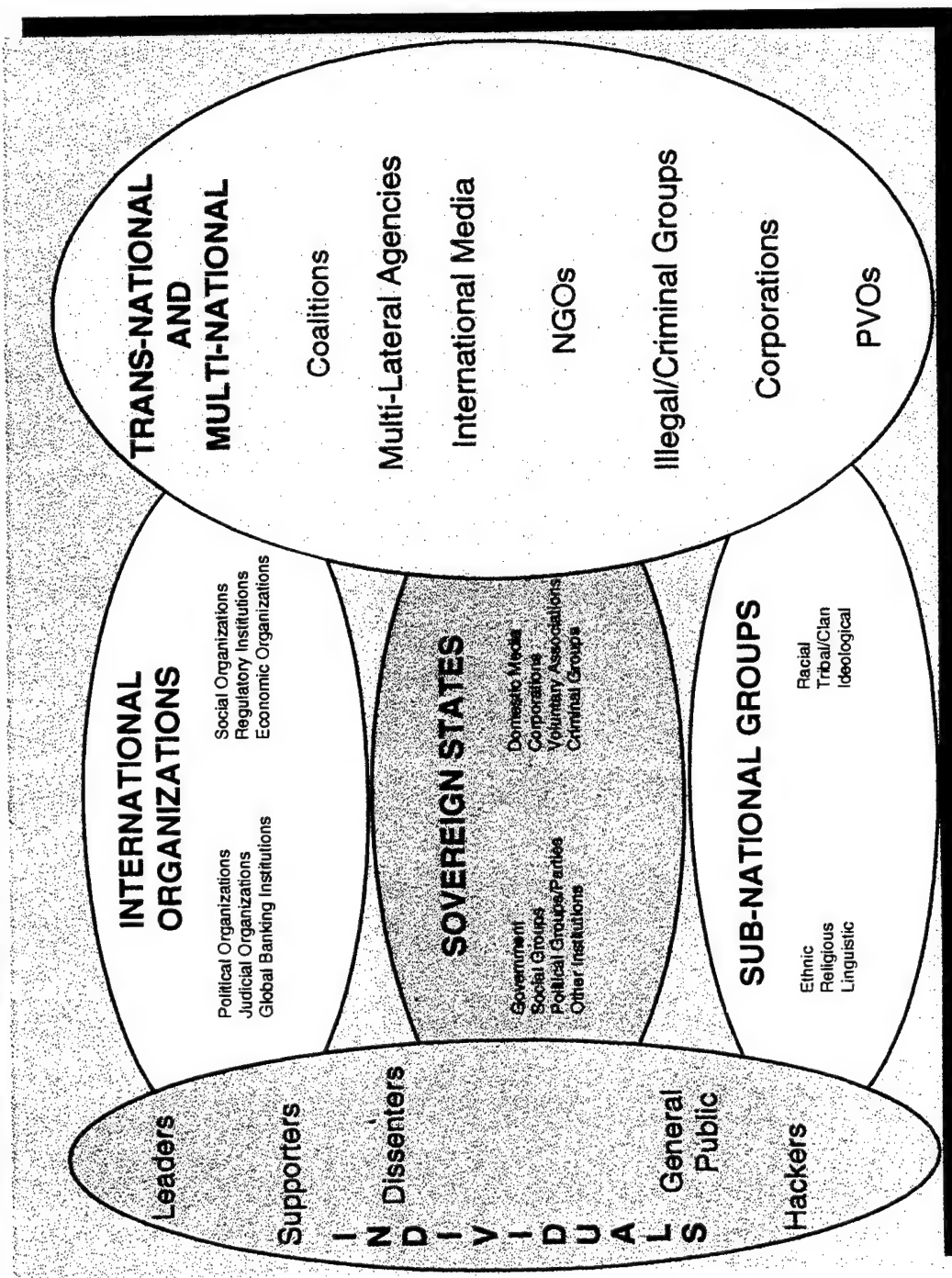


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Types of Entities





Means to Challenge U. S. Interests



- Conventional Weapons in Unconventional Conflicts
- Weapons of Mass Destruction against:
 - U. S. territory or population
 - U. S. forces
 - Allies or strategic states
- Terrorism
- Environmental Warfare
- Information War
 - Media wars
 - Cyber war
 - C2 warfare
 - Infrastructure attacks
 - Computer attacks

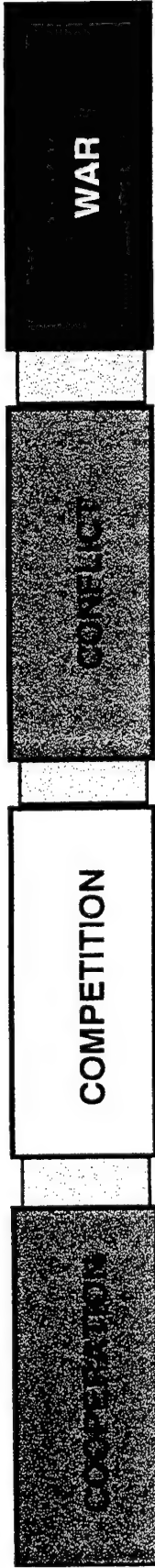


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Nature of Interactions



Fully Compatible,
Understood Goal
Sets

Goal Sets
Understood to
Differ Partially

Goal Sets
Perceived Largely
Incompatible

Goals Sets Perceived
Mutually Exclusive

Transition Zones Where Actors Perceive Crises



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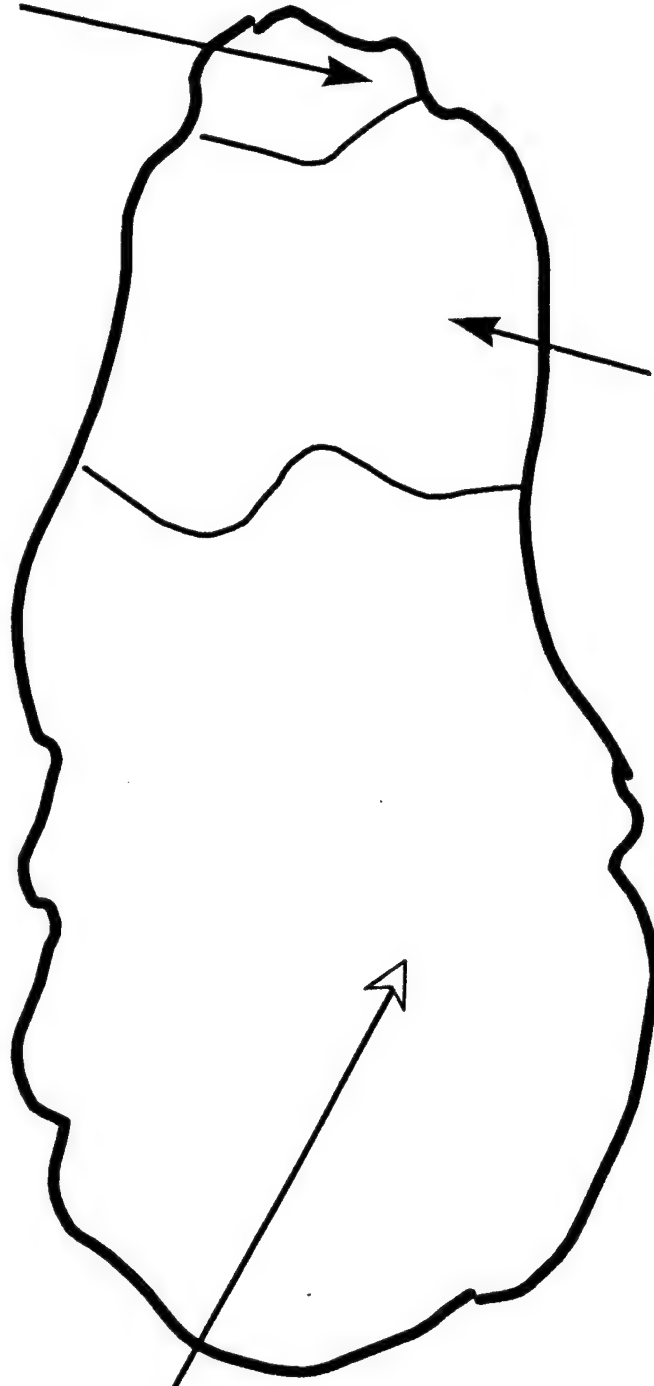


Threat Topology



Strategic

Everyday



Potentially Strategic

Consequences

Isolated / Limited

Catastrophic

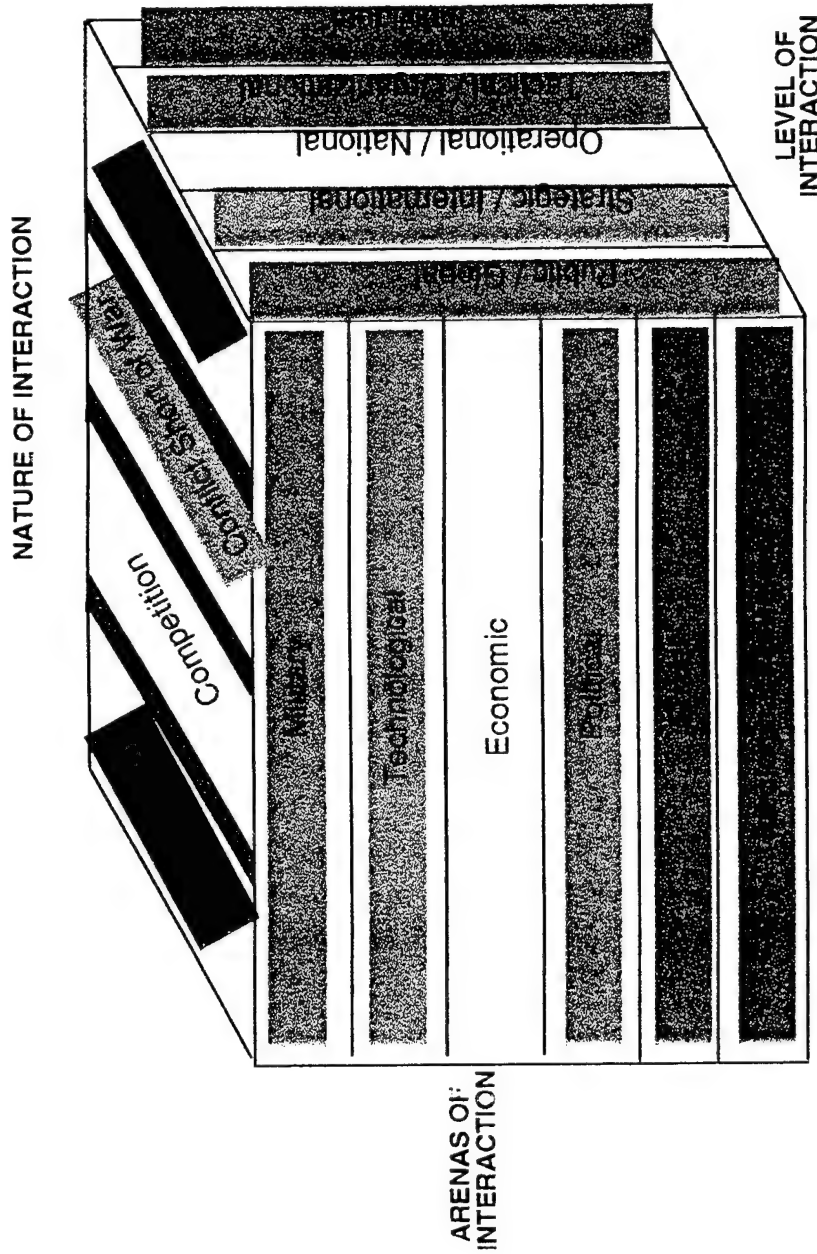


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Threat Space



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The Never Ending Story



- This is Not Your Father's OOTW
- Sources of Frustration
 - Slow to Develop, Slow Resolution
 - Complex Situation
 - ~ Progress Difficult to Measure
 - ~ Public and Political Leaders Impatient
 - Military Expertise Not Enough
 - ~ Political
 - ~ Social
 - ~ Economic
 - ~ Cultural
- Preventive Defense Makes OOTW Inevitable



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The Military Cannot Accomplish OOTW Missions Independently



- Threat/Environment Combination is Too Complex
 - Domestic Threats Linked to International Threats
 - ~ Law Enforcement and Intelligence
 - ~ Emergency Preparedness
 - ~ State and Local
 - Foreign Emergencies and Threats
 - ~ Host Governments
 - ~ Coalition Partners
 - ~ UN and Other International Organizations
 - ~ Non-Government Organizations



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The Military Cannot Accomplish OOTW Missions Independently (Continued)



- Media and Public Opinion
- Missions are Almost Never Purely Military
 - Bosnia
 - Haiti
 - Somalia
- Changes Needed In
 - Planning
 - Task Organization
 - Implementation



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Intelligence For OOTW Is A Heroic Undertaking



- Military Intelligence is Based on Platforms, Command Centers, Military Leaders, and Adversary Military Capabilities
- OOTW Requires Changes In
 - Collection Plans
 - Collection Priorities
 - Fusion Processes
 - Analytic Priorities and Focus
 - Presentation
 - Distribution and Dissemination
- Broad Intelligence Sharing Involves Risks of
 - OPSEC
 - Counter-Intelligence



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OOTW: The Never Ending Story



OOTW:

- Involve complex situations that have developed over time and will continue to change
- Challenges both the military and American society
- Requires picking defacto “winners and losers”



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Appendix C5 – Weapons of Mass Destruction

Appendix C5: Weapons of Mass Destruction

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BACKGROUND

The term "weapons of mass destruction" (WMD) is commonly used to describe nuclear, biological, and chemical (NBC) weapons, but the group concluded that using the specific weapon types (or the term NBC) was more appropriate because in reality the impacts of each of these weapons is quite different. Moreover, they will likely have very different employment characteristics, cause different responses to an opponent's employment, and we (the analysis community) have different levels of capability to model the weapons and different levels of confidence in the model results.

Many in the community tend to believe that NBC weapons are well handled in models because the effects of these weapons are part of physical science, as indicated in Chart 1. While this is true of some basic NBC effects such as nuclear blast overpressures, the entire chemical and biological weapons areas and nuclear fallout

depend upon accurate represent of atmospheric transport and diffusion, which is an imprecise "science" (especially when associated with surface winds) having many uncertainties. Other effects like electromagnetic pulse (EMP) also have significant uncertainties. But the key issues associated with representing the effect of NBC weapons go well beyond the physical effects models into the areas of the operational and strategic effects of these weapons, to include casualties caused, sorties reduced, lift and logistics throughput lost, reductions in combat effectiveness, and the impact these weapons would have on the strategic decisions of the United States and its allies. Estimating these effects is a far more subjective endeavor; few models attempt to do much in these areas, and those which do tend to be partial representations that are very rough approximations. The other key issues are the ability of the United States to deny the effectiveness of adversary NBC attacks or to use a combination of denial and retaliation to deter adversary use of NBC weapons, but these issues have

similar uncertainties and limitations in existing models.

DESCRIPTION OF THE PROBLEM

Chart 2 became the framework for our discussions. We first asked whether or not NBC weapons would make a difference in future conflicts. If they do not make a difference, then adversaries would have little reason to use these weapons and we would have little need to model their effects. Alternatively, if these weapons could have an effect but adversaries would all be afraid to use them, then this deterrence would allow us to also generally ignore NBC weapons. But if NBC weapons could make a difference, we need to do analysis of both how much impact these weapons could have and how the United States could deny their effects and/or retaliate against their use, hoping to achieve deterrence.

We concluded that NBC weapons could well make a big difference in future conflicts. It is clear that if they lacked protection from NBC weapons, U.S. forces would suffer substantial operational and strategic losses, as shown on Slide 3. Operational losses would include military and civilian casualties and a reduced ability of military forces to operate (e.g., simply having to wear protective clothing, or having to bury those who had died from such attacks to avoid a public health disaster). NBC use could affect coalition formation and even U.S. resolve. Moreover, the group concluded that the likely magnitude of such effects (that is, the extent of the U.S. vulnerability if unprepared) would significantly increase the probability that an adversary would use these weapons.

Several prospective adversaries of the United States seem to have concluded that the United States and its allies are vulnerable to NBC weapons, as reflected in their efforts to build these weapons: Unclassified estimates put Iran's current chemical weapons (CW) inventory at 2,000 or so tons while North Korea's inventory may be as much as 5,000 tons. (1) These numbers are about one-fifteenth and one-sixth of total U.S. stockpiles, for comparison purposes, and are far larger than required simply for only strategic (coercive)

purposes; an operational interest clearly motivates such large stockpiles. For North Korea, "Chemical weapons can be delivered by virtually all DPRK fire support systems. This includes most artillery, multiple rocket launchers (including those mounted on CHAHO-type boats), mortars, FROG and SCUD missiles, and some bombs." (2)

PAST EFFORTS

The consensus of the group was that the Bottom-Up Review (BUR) of 1993 only superficially treated the implications of NBC use, essentially acting as though NBC weapons would not make a difference in two Major Regional Conflicts. The Nuclear Posture Review (NPR) examined deterrence of NBC use, but the primary focus of the NPR was on strategic nuclear forces and not on NBC weapon use at the theater level.

There have been many studies of NBC use and the U.S. reaction to it, but these studies are not widely known across the analytic community. Specific efforts discussed included:

BDM: Counterproliferation studies.

CNA: Counterproliferation studies.

DSWA (formerly DNA): Analysis of theater operations under NBC attacks, work on air crew performance and personnel performance in the presence of CBW.

IDA: Counterproliferation studies.

Joint Staff (J-8): Counterproliferation studies.

RAND: "Day After..." games, counterproliferation studies.

SAIC: Counterproliferation studies.

US Air Force: Salty Demo exercise, counterproliferation studies.

US Army: Effectiveness of active TMD, soldier performance in NBC environments.

For scenario data, the Army War College, the Joint Staff (J-5 and J-8), the National Defense University, OSD/Strategy

and Requirements, and RAND were suggested as sources of information.

Mr. Walt Hollis (Deputy Undersecretary of the Army for Operations Research) is heading a study to compile a list of models which can be used in the NBC area. Mr. Walt Zimmers of DSWA has compiled a list of NBC models and directly supports many of them.

Stan Stafira and Greg Parnell's paper to be published in Management Science was suggested as a good macro system selection technique.

PRESENTATIONS RECEIVED

Title: Stability, Risk, and Deterrence

Presenter: Dr. Roy Rice, Teledyne Brown

Overview: This presentation related an effort undertaken about 6 years ago by the author (then serving on the Joint Staff) in support of joint U.S./Russian military talks on strategic nuclear forces. It evaluated the impact of varying strategic warhead levels on stability, risk, and deterrence, based upon an assessment of the utility each side would have for damage achieved and damage suffered.

Title: Use of CBW in Regional Conflicts

Presenter: Dr. Bruce Bennett, RAND

Overview: This presentation served as an introduction for this panel, discussing and developing the broad issues which would be considered. Several examples were used to clarify the complexity of the issues and the impact CBW could have.

GROUP DISCUSSION

The United States already takes a number of measures to mitigate the potential use of NBC weapons or to prevent their use. Chart 4 outlines these measures. Chart 5 shows a notional example of the trade-off space for denial actions. In addition, a full assessment would have to look at changing U.S. force operations to limit vulnerability (e.g., dispersing forces), and alternative adversary strategies for using NBC weapons. The various mitigating actions allow the United States to reduce the damage that an adversary can cause, though early in a conflict many active defenses may still need to be

deployed, and the counterforce effort might be hampered by inadequate surveillance capabilities and forces tasked to other missions (such as the suppression of enemy air defenses). A large vulnerability early in a conflict suggests that the United States and its allies cannot afford to give the complete initiative to our prospective adversaries, and may need to be prepared to preempt certain kinds of attacks once an adversary attack is initially launched.

Chart 6 presents two of the U.S. retaliation options: redressing and punishment. The difficulty with punishment and also with sanctions (the other element of retaliation) is in finding an action that will so threaten a prospective adversary that that adversary will choose not to use NBC weapons as the result of U.S. coercion. What does the adversary value so greatly? Would economic sanctions which likely affect the population and not the leadership adequately impact a totalitarian adversary's decision process (such appears not to have been the case with Iraq)? Or is punishment required which is, for example, focused on the opposing leader's newest palace? Other issues which must be considered include collateral damage and the broader implications of the U.S. action on its relationships in the region and around the world (e.g., how would other countries perceive a U.S. nuclear strike against the adversary? Would the United States appear to be the true villain, even though the adversary first used CBW?).

Redressing means taking alternative actions to restore combat capabilities lost in NBC attacks. For example, if an adversary has attacked airfields, preventing the aircraft based there from destroying some number of adversary armored vehicles, then the United States needs to find another way to kill those armored vehicles, and thus offset the implications of the damage suffered from the CBW attack. Usually, redressing is not very effective against symmetric targets (e.g., U.S. attacks on adversary airfields in response to adversary NBC attacks on U.S./allied airfields will not redress the U.S. losses since adversary air forces are likely to be of little value to his strategy); instead, redressing needs to focus on centers of gravity of the adversary's strategy, which in MRCs is likely the adversary's ground forces, power projection capabilities, and its NBC weapons.

The real goal is deterrence: The United States does not want to fight a war in which the adversary uses NBC weapons. Chart 7 suggests a more complete framework for deterrence than is normally discussed in the community. An adversary considering the use of NBC weapons must balance what he perceives he will gain from using those weapons versus the losses he feels he will suffer. U.S. and allied denial actions can significantly reduce the adversary's potential gains, leaving relatively little value to most aspects of NBC use. If at the same time the adversary understands that U.S. and allied retaliation will be severe, deterrence can be achieved by making the adversary feel that he will lose more than he can gain by using NBC weapons. But fundamental to analyzing this balance is the question: What are the potential adversary's perceptions regarding gains and costs? What is his value structure? How does deterrence work on him? A framework like that presented by Roy Rice may be useful in making such an assessment, but one must also consider cultural and other differences of the adversary's leadership who will in the end be assessing this trade-off.

ANALYTIC OPTIONS

Chart 8 shows the group's opinions concerning the analytic approaches appropriate for analyses lasting two days, two weeks, or two months. Paramount to these views was the group's perception of the need for a "warm" base of information; however, the current analytic base is very segmented. Knowledge of NBC weapons and means for their use are not widely held across the community; for example, most experts on analysis of general purpose force operations know little of the implications of NBC use, and even most experts in strategic nuclear targeting know relatively little about chemical weapons effects. Because of the complexities of NBC weapons, an analyst starting from a "cold" base would be hard pressed to develop correct or useful analytic results for decision makers.

The chart indicates our feeling that as the amount of time available for analysis increases, the depth and breadth of analysis can increase. With only two days to

perform an analysis, the group felt that templates or "rules of thumb" applied to generic targets and operational strategies would have to be employed. These rules would likely be employed independently in the various areas requiring assessment, and the integration across issues would be done on the "back-of-the-envelope," at best. Unfortunately, the community has not developed an agreed set of templates or "rules of thumb," and given the uncertainties in NBC weapons effects, it would not be surprising to find different analysts using very different methods and data. As the time available for analysis increases, better modeling could be used and more trade-off space analysis performed, but the uncertainties and differences between the models might be responsible for only a modest reduction in the differences between the work of various analysts.

RECOMMENDATIONS

To support the Quadrennial Defense Review (over the next 6 months to a year), the community needs to:

- Collect templates and rules of thumb that already exist.
- Develop some new templates or rules of thumb.
- Identify a list of experts in each area identified in Chart 8, get those experts to meet together, and have them recommend how the templates/rules of thumb should be used, and the uncertainties associated with them.
- Develop a "Red Team" group which postulates and tests potential adversary employment concepts for NBC weapons, and works with the intelligence community to find evidence of these concepts developing.
- Investigate the value structure of prospective adversaries, and postulate their attitude on deterrence and their reaction to various retaliatory threats.
- Construct Blue operational concepts for defense against NBC weapons. These would include both new ways of operating U.S. and allied forces (e.g., lower force densities, remote sensing, stand-off fires, ...) and ways for

integrating the evolving defenses into U.S. and allied force operations.

With regard to longer-term analytic requirements, the community needs to:

- Develop better models of atmospheric transport and diffusion, and the character of chemical and biological weapons (e.g, defining better the persistence of these weapons).
- Develop better models of human/target effects. We need a better understanding of toxicity, protection, detection, and identification respecting chemical and biological weapons.
- Work on integrating models in each of the areas identified on Chart 8 into theater analysis procedures, so that the impacts of NBC weapons on theater conflict can be better understood.

(1) "Tehran may have produced up to 2,-000 tons of chemical agents, including mustard, cyanidal and possibly sarin nerve gas. It may also be researching anthrax and botulin toxins." Michael S. Lelyveld, "Report: Iran Has Huge Weapons Stockpile," Journal of Commerce, March 29, 1996, p.1/3. "The agency [CIA] also disclosed the regime [Iran] has a chemical weapons stockpile of 'several thousand tons of CW agents including sulfur mustard, phosgene and cyanide agents, and Tehran is capable of producing 1,000 tons of these agents each year." Tony Capaccio, "CIA: Iran Holding Limited Stocks of Biological Weapons," Defense Week, August 5, 1996, p. 1. "...North Korea is estimated to have up to 5,000 tonnes of chemical weapons,..." "Military Estimates DPRK Chemical Arms Stocks," Seoul Sinmun (translated by FBIS), April 15, 1995, p. 1.

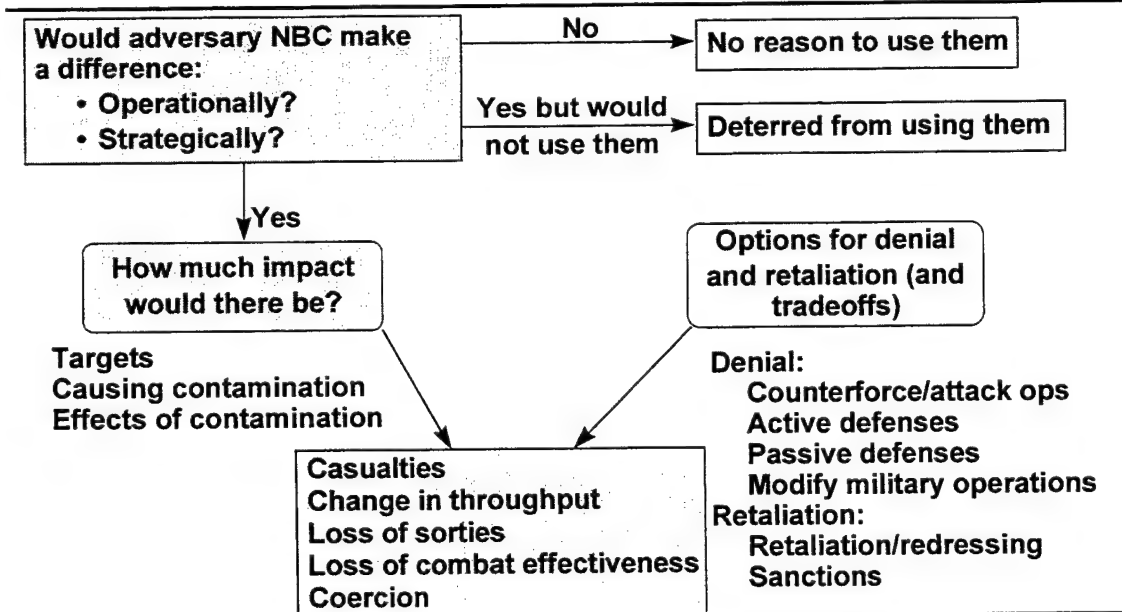
(2) Defense Intelligence Agency, North Korea Handbook, PC-2600-6421-94, 1994, p. 3-16.

An Introduction to the NBC Methodology

- The key issues**
- In the NBC area, there are lots of physical effects models
 - Some (prompt nuclear effects) are relatively well established
 - Some (CBW, fallout) have big uncertainties with atmospheric transport and other factors (e.g., EMP)
 - But the more important issues are operational and strategic impacts of NBC use
 - Casualties (military *and* civilian)
 - Combat effectiveness, sorties, lift & logistics throughput, ...
 - Community has some methodologies here but not enough and not a consistent picture
 - Denial capabilities can mitigate these effects
 - Denial and retaliation capabilities may deter use

Quick Reaction Analyses/Methodologies-1

Framework for Our NBC Discussions



Quick Reaction Analyses/Methodologies-2

Would Adversary NBC Make a Difference?

In face of serious NBC attacks, without protection

- **Operationally**
 - C4I facilities, ground forces lose some operational effectiveness
 - Airfields lose sortie production and lift throughput
 - Ports, logistics facilities lose lift throughput
 - Even naval forces can be incapacitated
 - **Strategically**
 - Psychological effects of NBC threat or use would be substantial; amplified after first effective use
 - Many casualties could occur (military and civilian, U.S. and allied)
 - U.S. could face either a loss of will or a significant escalation
 - Adversaries have coercive potential; historical escalation dominance may not hold
-

**Magnitude of potential effect increases the probability
that an adversary will use these weapons**

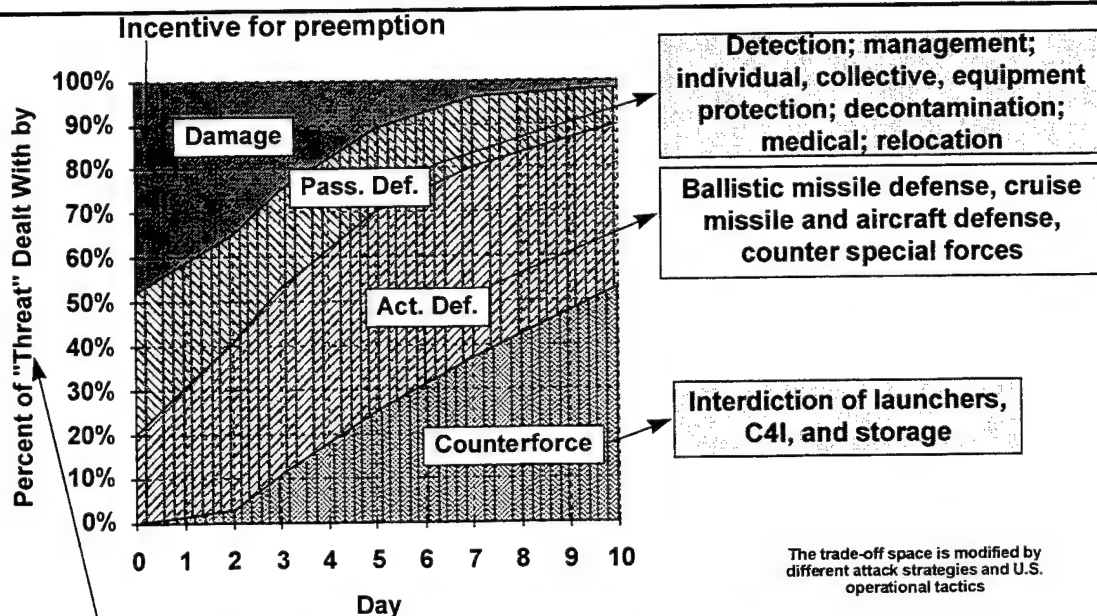
Quick Reaction Analyses/Methodologies-3

Methods for Evaluating Denial and Retaliation

- **Denial (mitigating NBC use, at a cost)**
 - Counterforce/attack ops
 - Active defenses
 - Passive defenses
 - Modified force operations
 - **Retaliation**
 - Punishment
 - Sanctions
 - Redressing
 - **Deterrence**
-

Quick Reaction Analyses/Methodologies-4

Denial Trade-off Space



"Threat" is a very broad term which includes all aspects of a successful attack

These numbers are notional

Quick Reaction Analyses/Methodologies-5

Enhancing U.S. Retaliatory Options



Weapon choice:

Need conventional withholds as threat, for deterrence

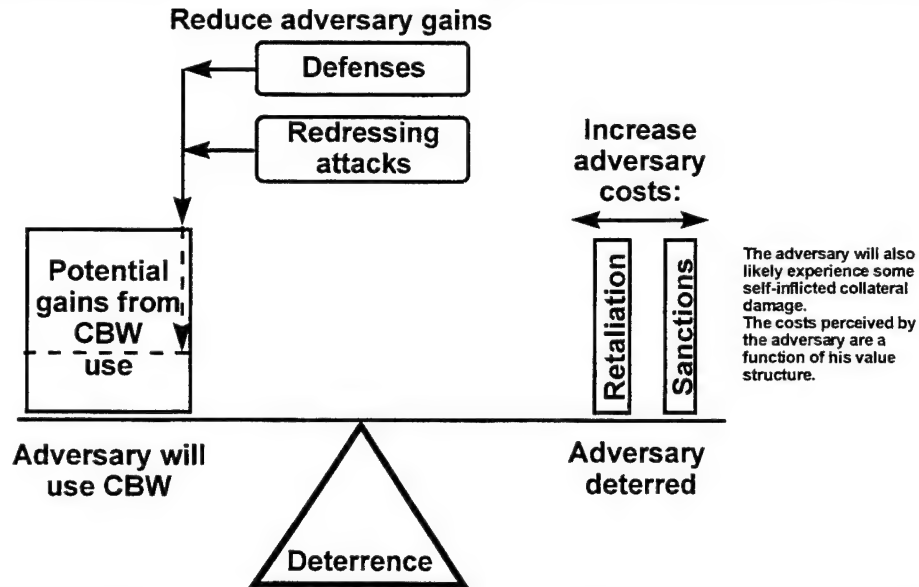
Nuclear first use is politically hard; must use care in targeting

CBW use eschewed

Need to consider collateral damage, broad implications (political, regional)

Quick Reaction Analyses/Methodologies-6

Dealing with CBW Threats: Changing the Adversaries' Assessment



The U.S. can select actions that affect these calculations, but cannot control the final adversary tradeoffs. Utility curves may assist in making assessments.

Quick Reaction Analyses/Methodologies-7

Analytic Options Over Time

Area	2 days	2 weeks	2 months
Opn weapons effects: Casualties, diversion, morale, ...	Templates	Templates, rules	Models, rules
Targets	Stylized	Functional lists	Operatnl relations
Counterforce	TEL, supply, C4I kill rates	TEL, supply, C4I kill rates	Rates, models
Active defenses	Intercept rates	Intercept rates	Rates, models
Passive defenses	Protection, degrade factors	Factors and interactions	Factors, models
Modified operations	Templates (preemption, dispersed ops)	Options	Ops analysis
Punishment	U.S. target options	Escalation control	Escalation tracks
Redressing	Impact rules	Target analysis	Ops analysis
Integration/trade-offs	Back-ofenvelop	Back-ofenvelop	Explor. analysis

Assumes a "warm base" (conclusion drawn by "cold base" are likely wrong)
"Warm base" is incomplete today

Need to do now:

- Identify data sources, develop some data
- Begin campaign analysis (How would opponent use NBC, how would we respond?)

Quick Reaction Analyses/Methodologies-8

**DETERRENCE
STABILITY
RISK**

USST II BRIEFING

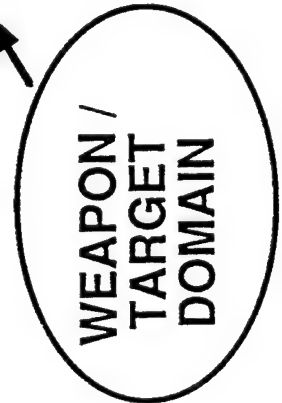
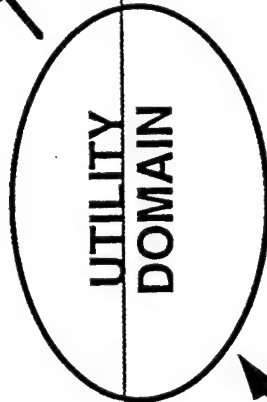
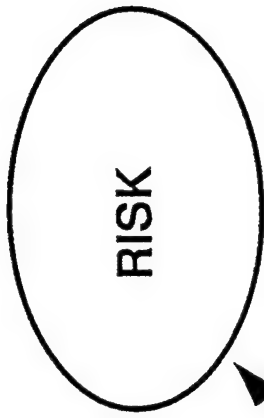
BY

MAJ ROY RICE

JUNE 1991

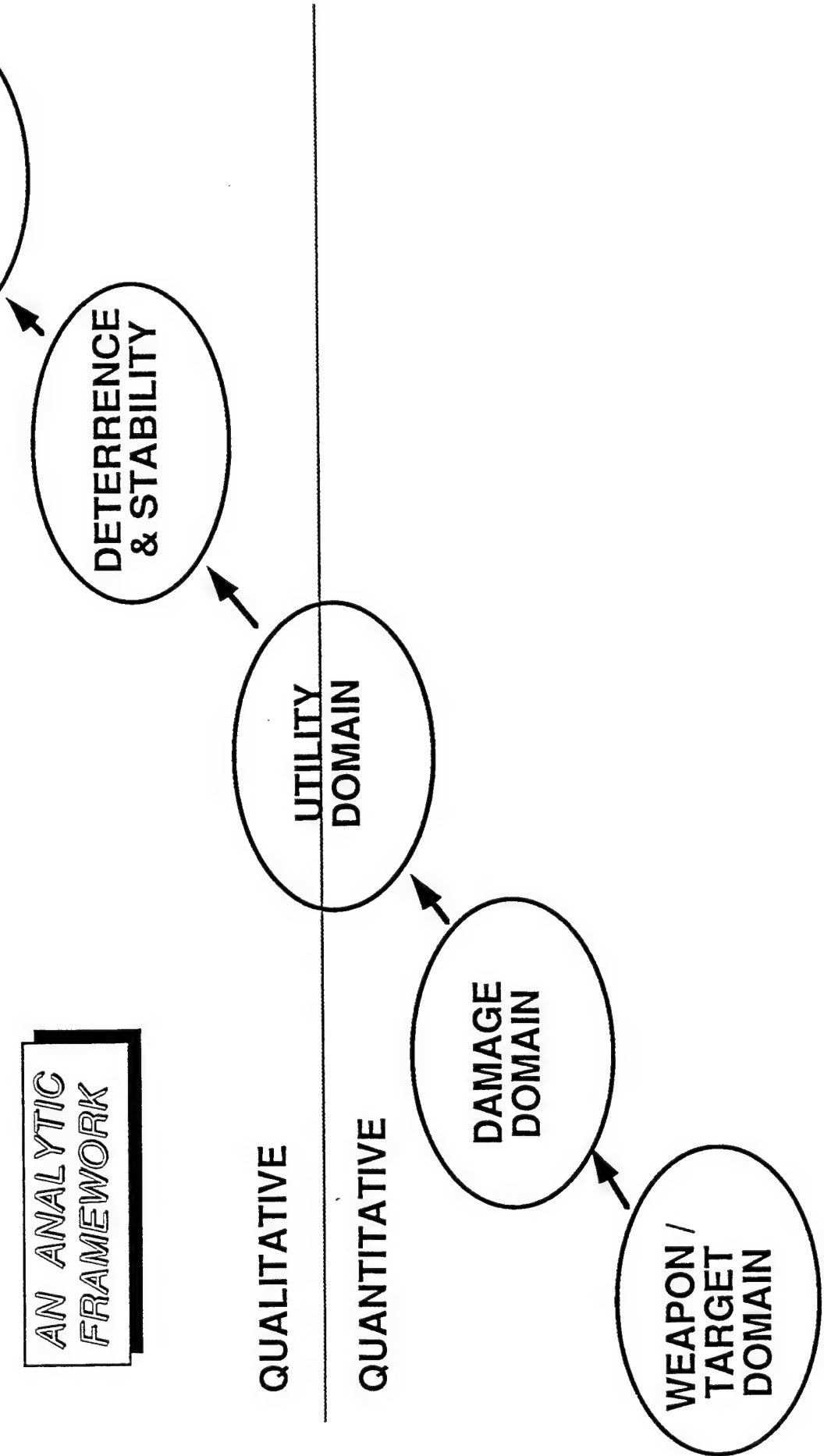
**DETERRENCE
STABILITY
RISK**

**AN ANALYTIC
FRAMEWORK**



QUALITATIVE

QUANTITATIVE



DETERRENCE STABILITY RISK

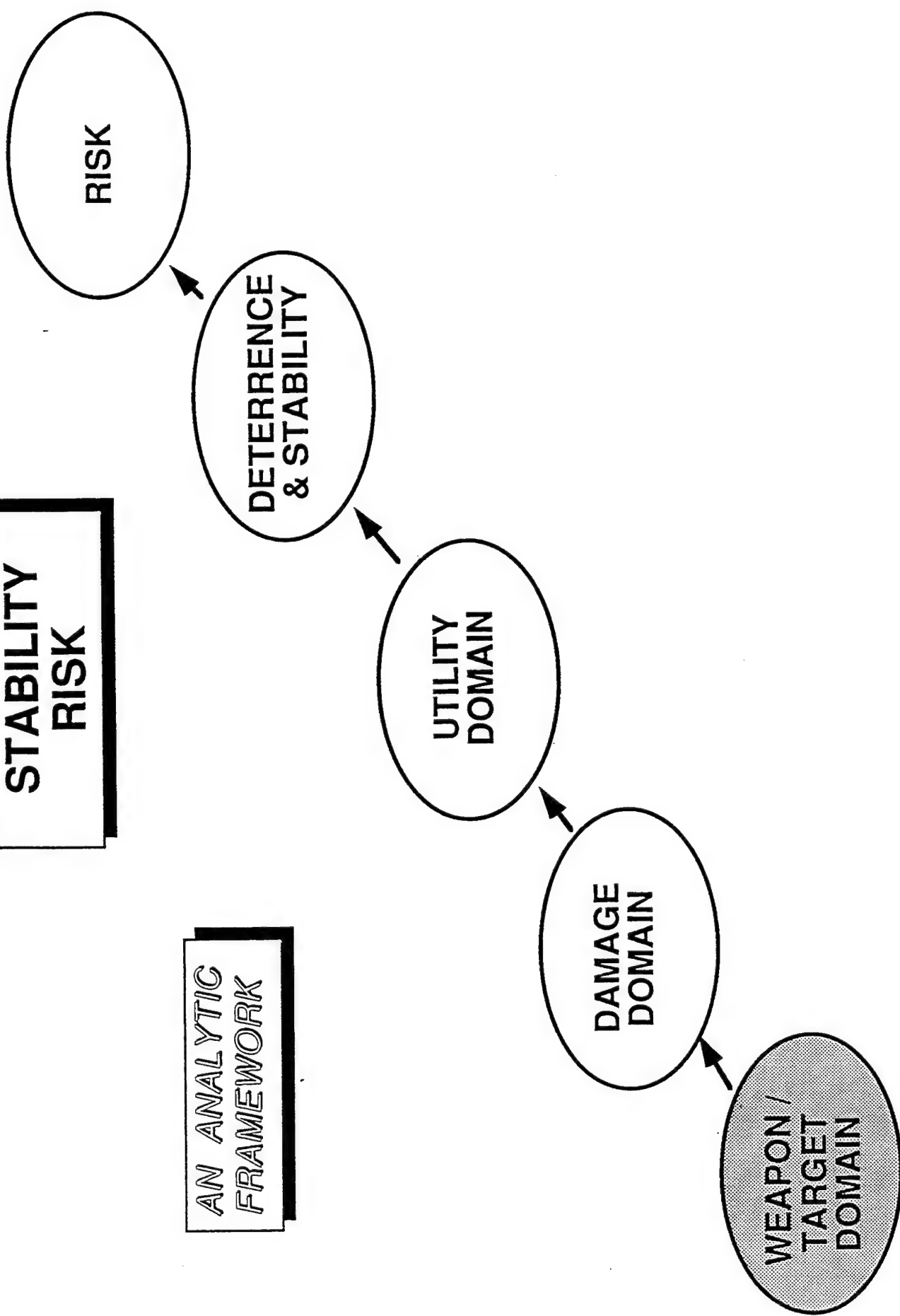
DETERRENCE DEFINITION: Dissuasion by threat of reprisal - - state of mind.

NECESSARY CONDITIONS:

- **COMPETITION**
- **RATIONAL PLAYERS**
- **CREDIBLE MEANS OF INFLUENCE**
- **WILL**

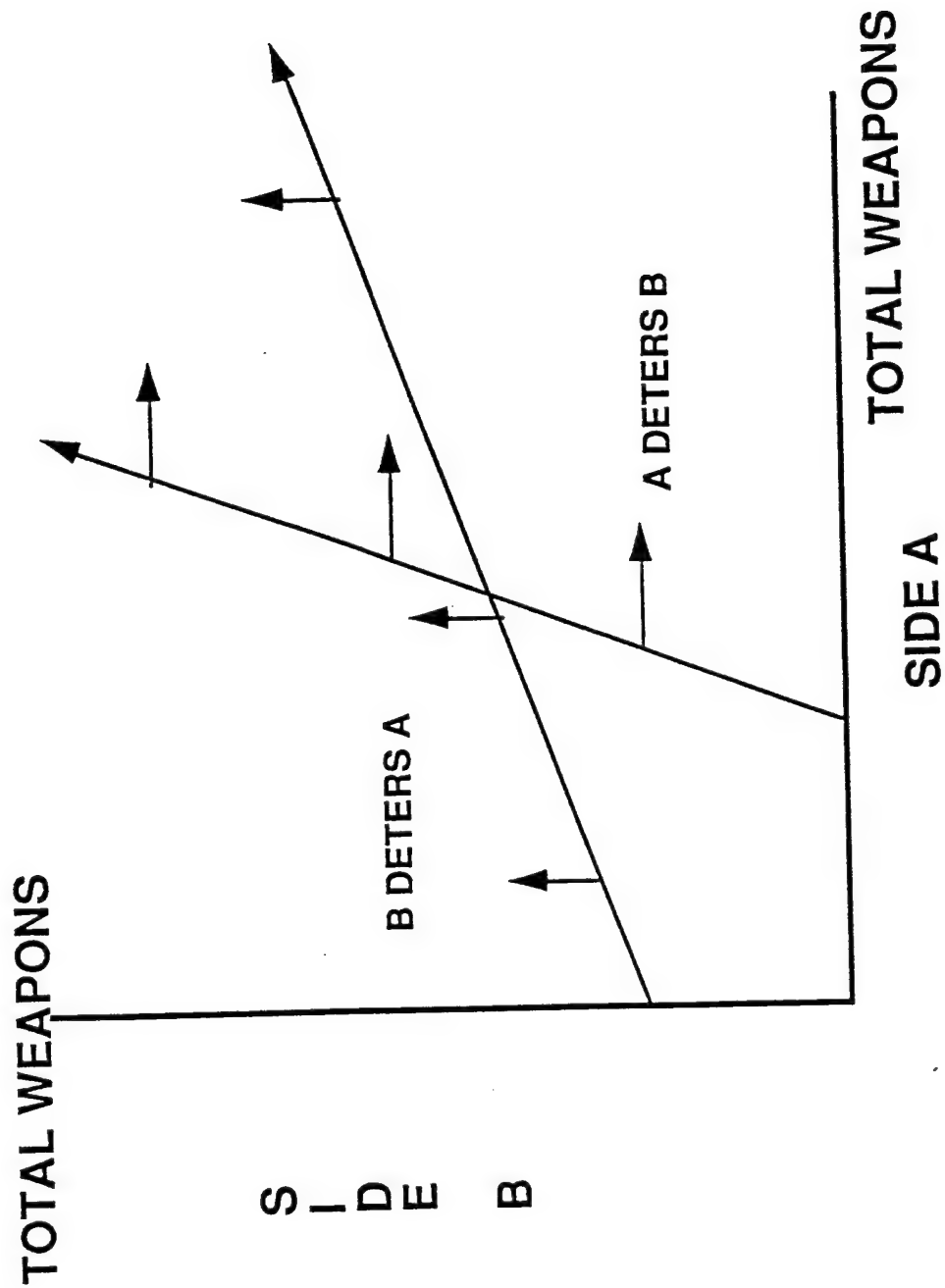
**DETERRENCE
STABILITY
RISK**

**AN ANALYTIC
FRAMEWORK**



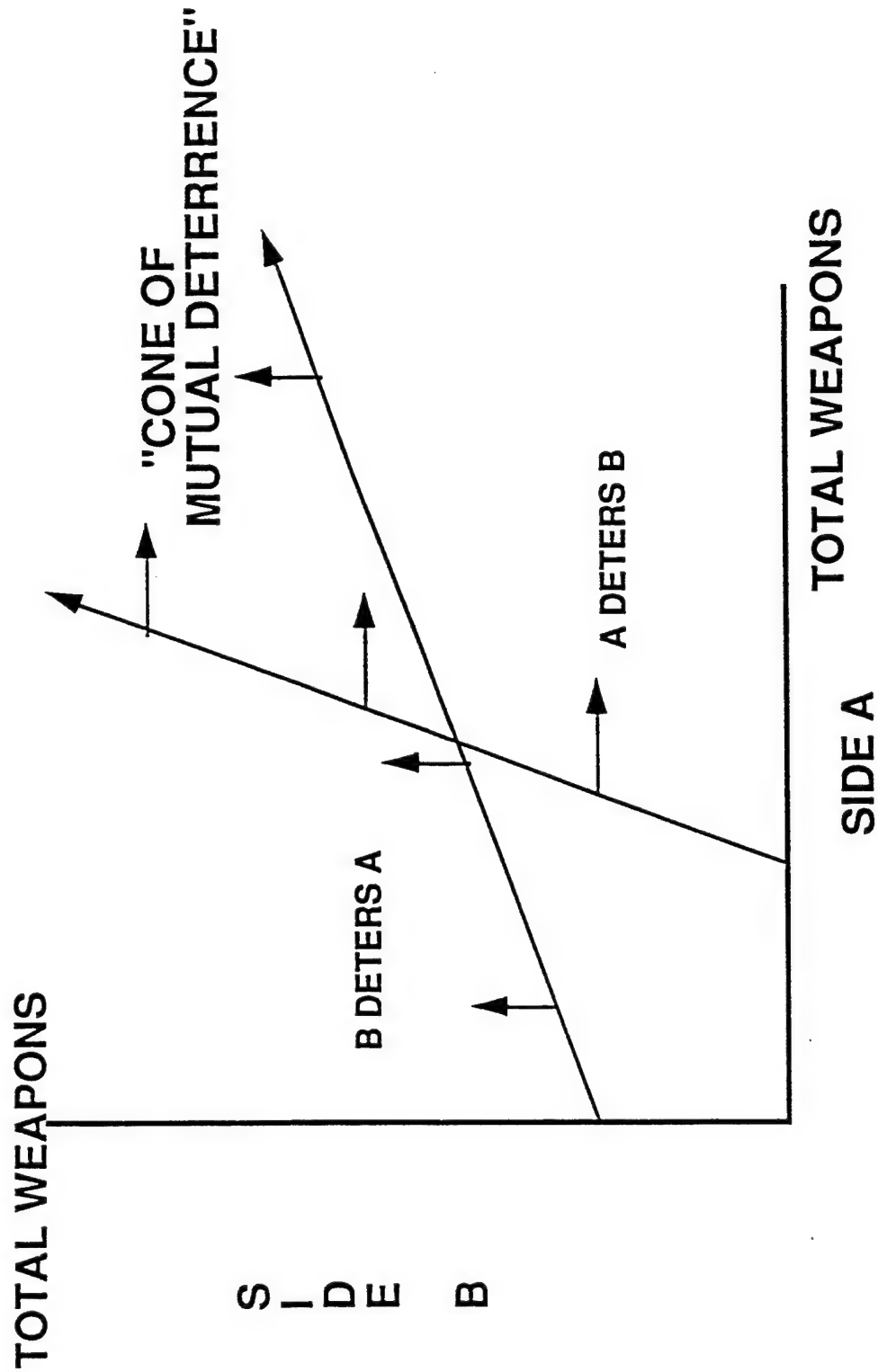
**DETERRENCE
STABILITY
RISK**

WEAPONS DOMAIN



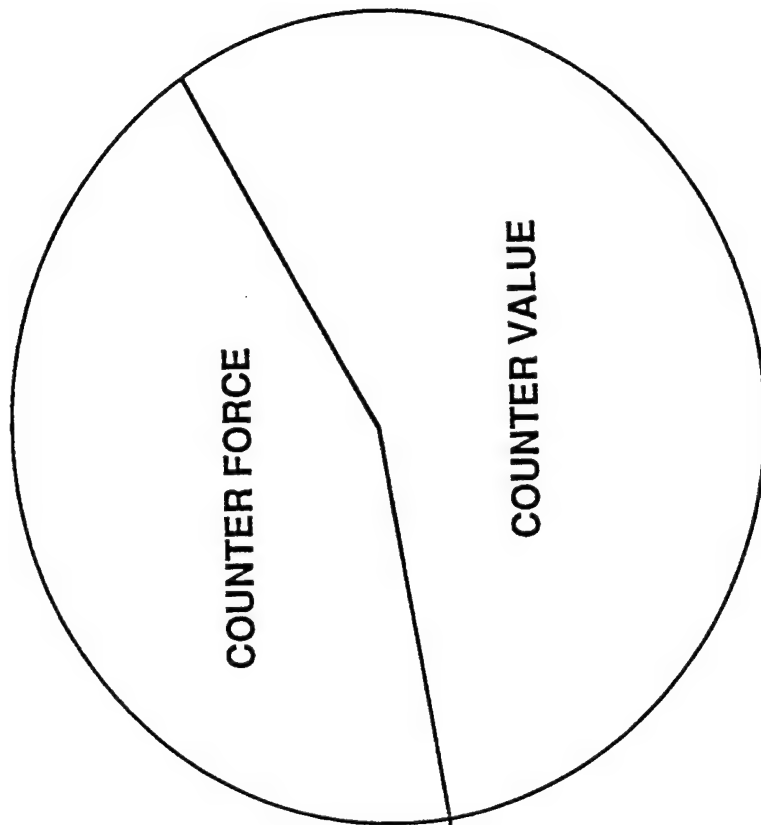
**DETERRENCE
STABILITY
RISK**

WEAPONS DOMAIN

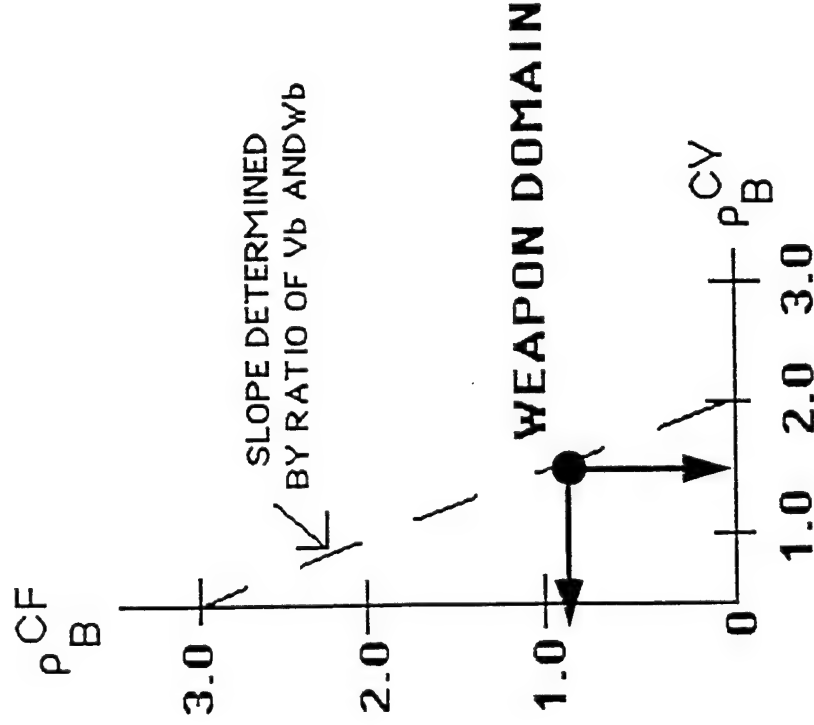


**DETERRENCE
STABILITY
RISK**

TARGET DOMAIN



DETERRENCE STABILITY RISK



ρ_B^{CF} = density of A's weapons allocated
 against B's counter force targets

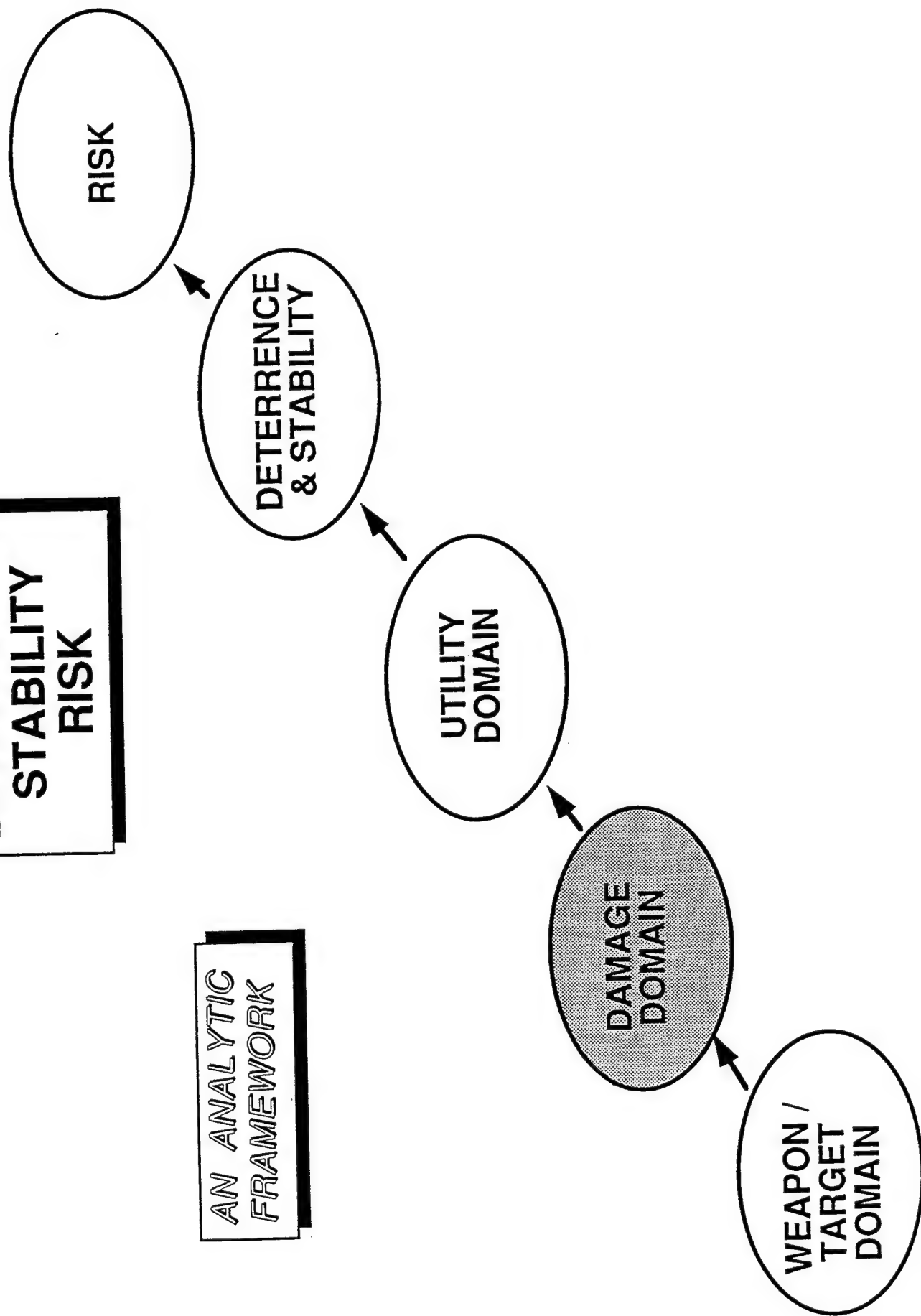
ρ_B^{CV} = density of A's weapons allocated
 against B's counter value targets

V_b = number of value targets B has

W_b = number of weapons B has

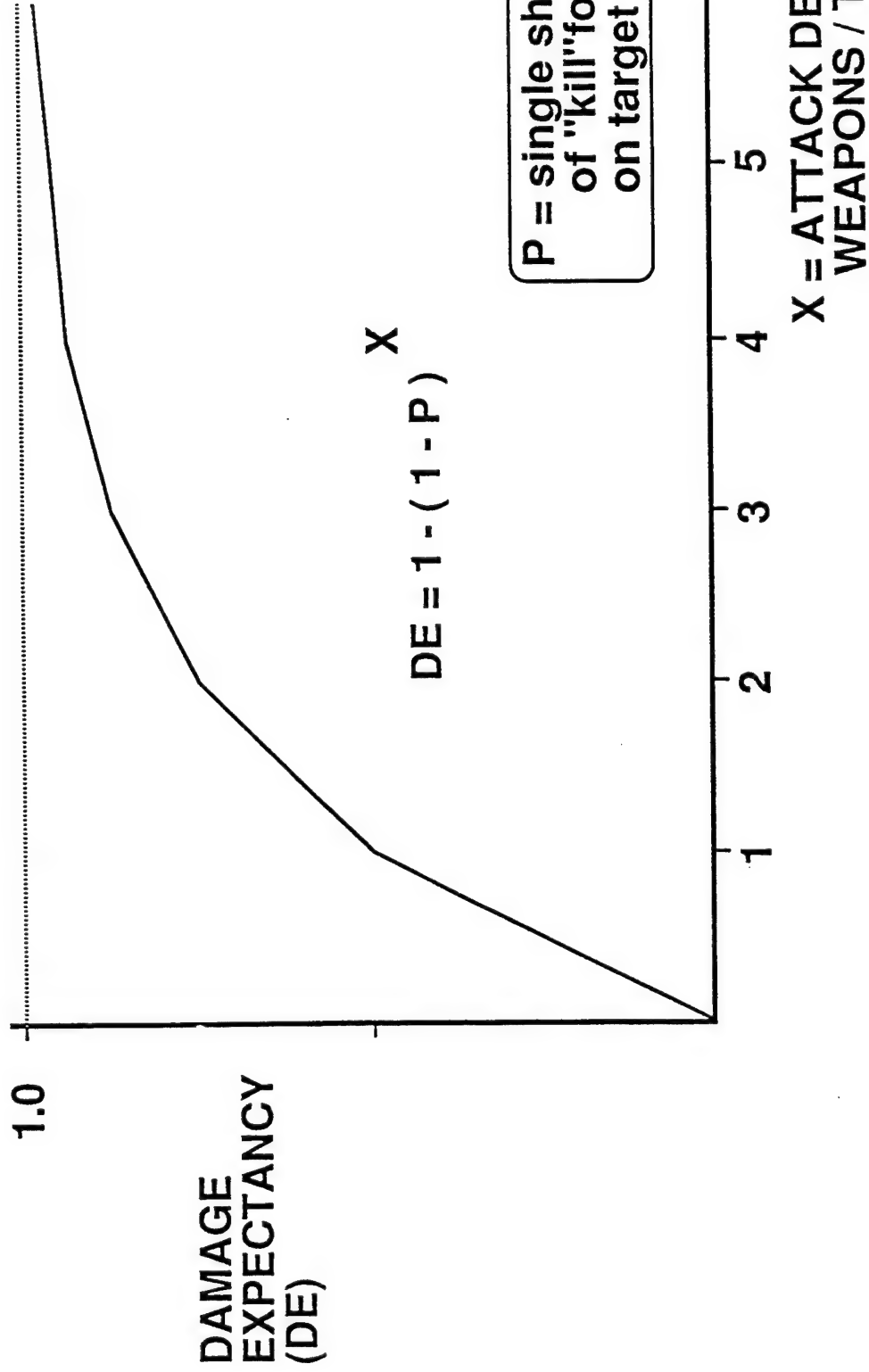
**DETERRENCE
STABILITY
RISK**

**AN ANALYTIC
FRAMEWORK**



**DETERRENCE
STABILITY
RISK**

DAMAGE DOMAIN



DETERRENCE STABILITY RISK

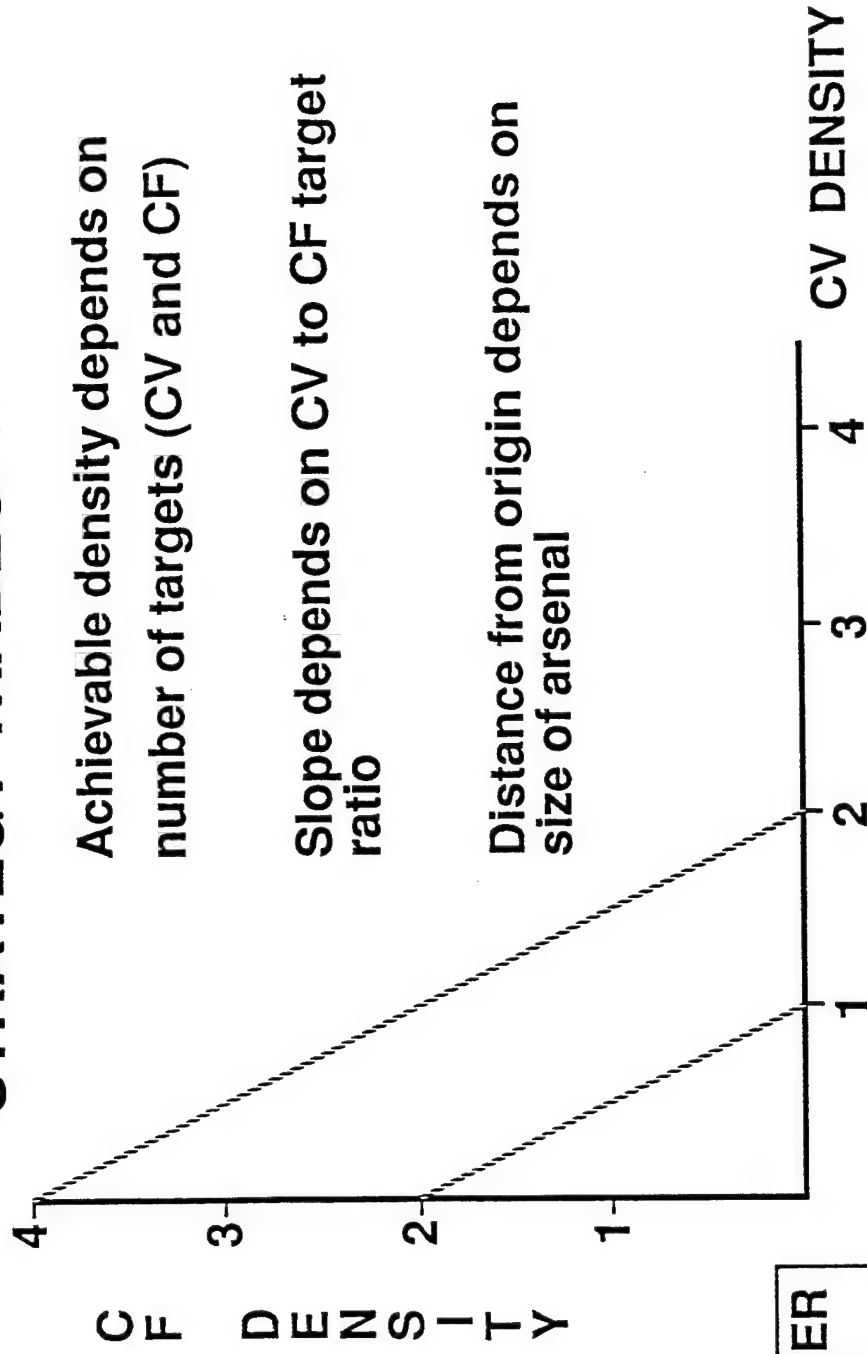
ATTACK STRATEGIES

ASSUMPTIONS:

- BOTH SIDES WILL PLAN THEIR ATTACK WITH SOME PORTION DEVOTED TO COUNTER VALUE (PUNISHMENT) AND SOME TO COUNTER FORCE (DENIAL)
- BOTH SIDES WILL OPTIMIZE THE UTILITY THAT THEY EXPECT TO RECEIVE BY CHOOSING THE PROPORTION OF THE ATTACK THAT WILL BE ASSIGNED TO EACH KIND OF ATTACK (RATIONAL)

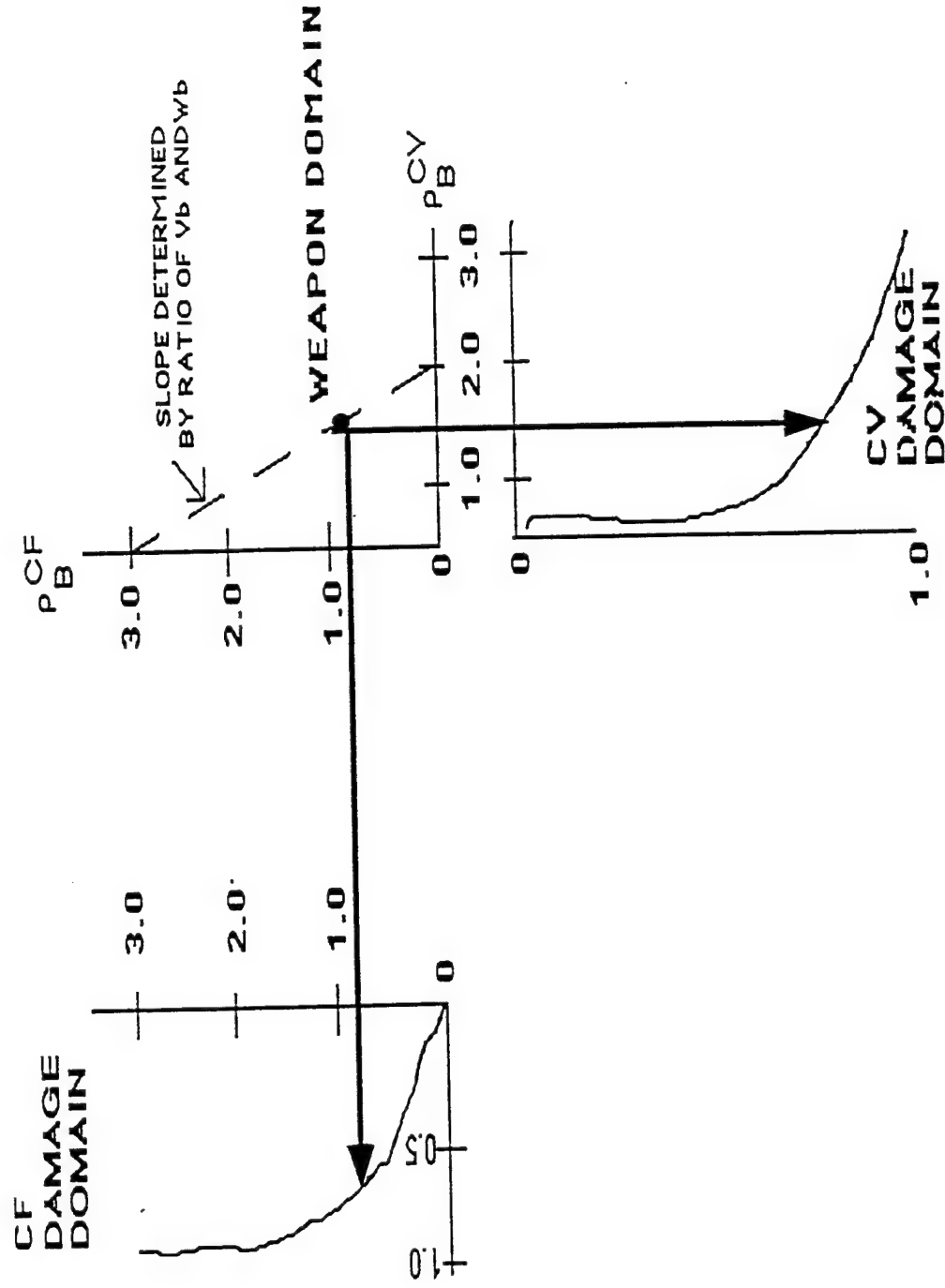
DETERRENCE STABILITY RISK

CF vs CV STRATEGY TRADEOFF



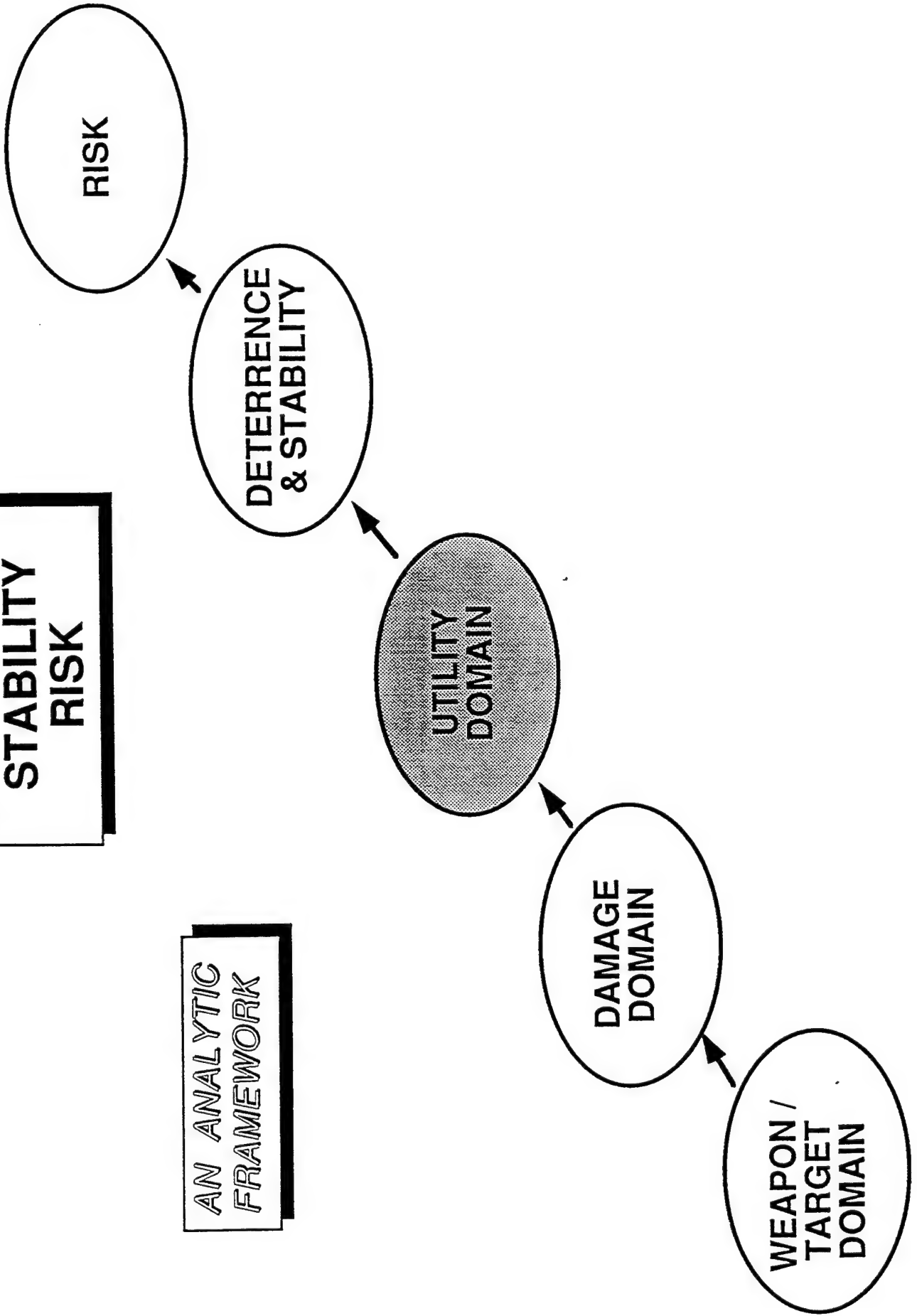
CF = COUNTER
FORCE
CV = COUNTER
VALUE

DETERRENCE STABILITY RISK



**DETERRENCE
STABILITY
RISK**

**AN ANALYTIC
FRAMEWORK**



DETERRENCE STABILITY RISK

QUALITATIVE /
QUANTITATIVE
INTERFACE

UTILITY DOMAIN

PREFERENCE ORDERING

- DONE BY EACH SIDE
- CAPTURES "VIEW OF OUTCOMES"

GIVEN A SITUATION, THERE ARE FOUR OUTCOMES

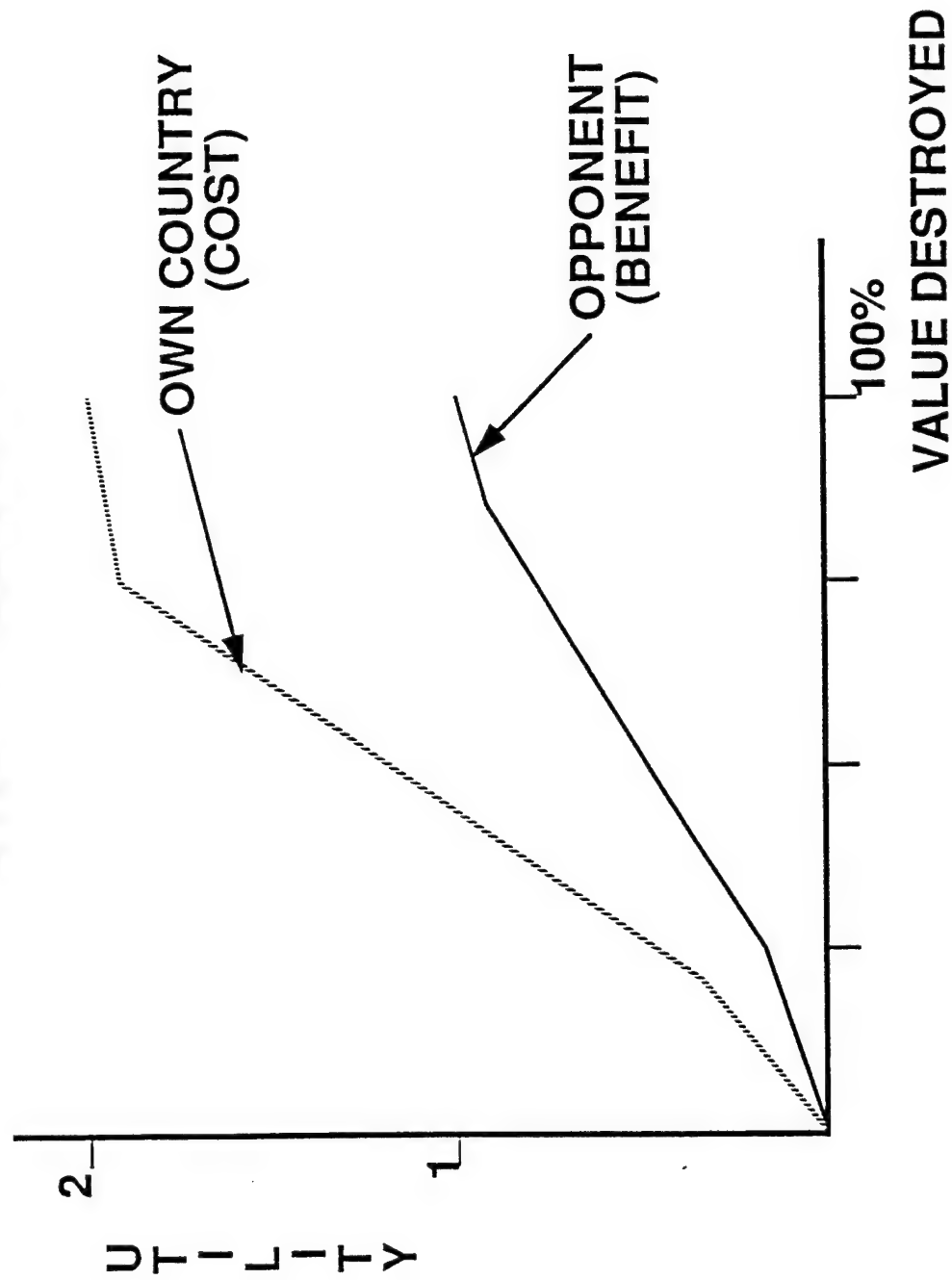
- | | | |
|---|--------------------|---|
| 1 | SIDE A DOMINATES | 4 |
| 2 | STATUS QUO | 2 |
| 3 | MUTUAL DESTRUCTION | 3 |
| 4 | SIDE B DOMINATES | 1 |

SIDE A PREFERENCE ORDERING	SIDE B PREFERENCE ORDERING
----------------------------------	----------------------------------

**DETERRENCE
STABILITY
RISK**

$$\text{TOTAL UTILITY} = \text{BENEFIT} - \text{COST}$$

UTILITY DOMAIN



DETERRENCE **STABILITY** **RISK**

UTILITY DOMAIN

UTILITY FUNCTION

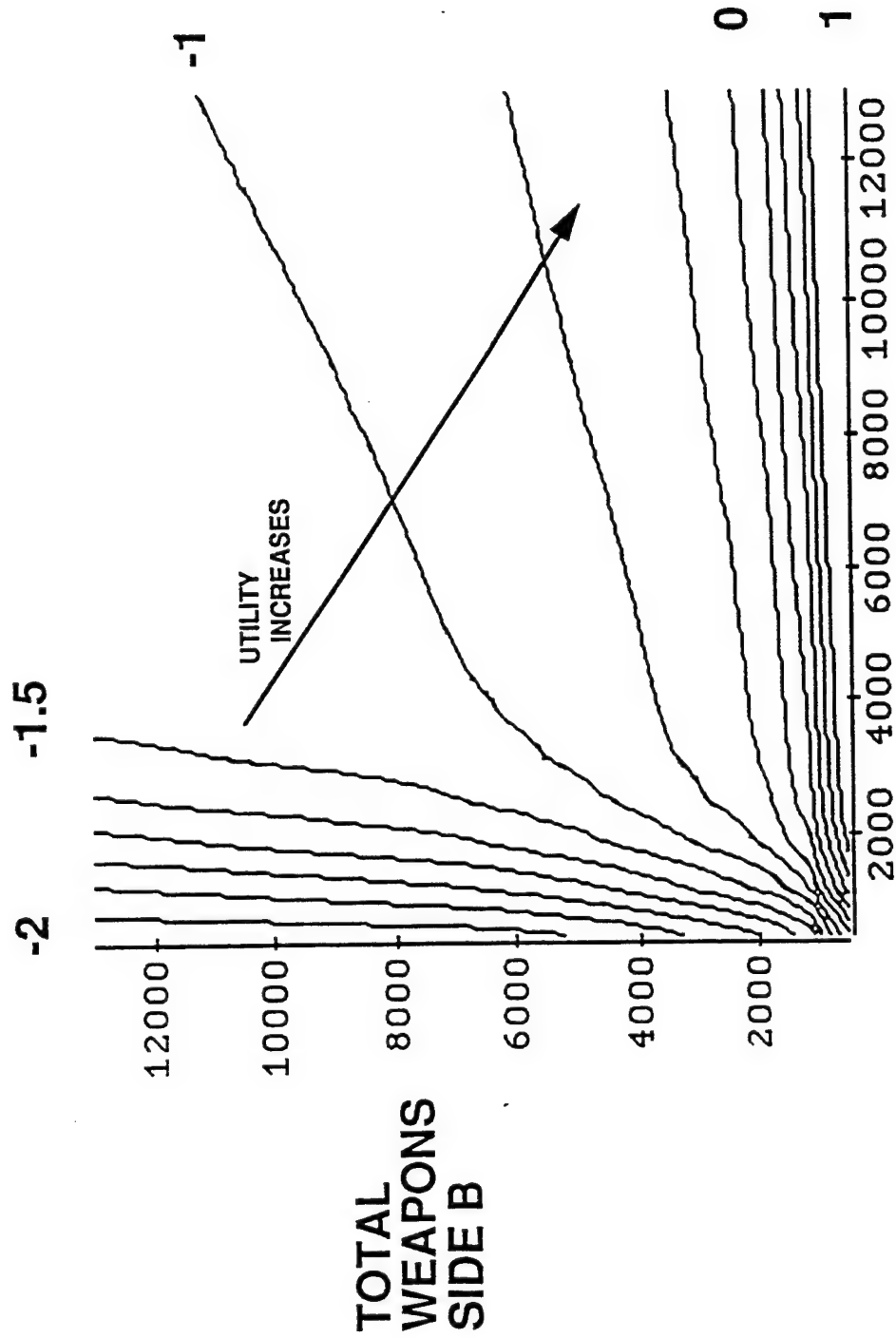
- CONSISTENT WITH PREFERENCE ORDERING
- E.G., UTILITY = BENEFIT - COST

GIVEN , UTILITY BY THIS FUNCTION IS:

A's <u>UTILITY</u>				B's <u>UTILITY</u>
+1	1	SIDE A DOMINATES	4	-2
0	2	STATUS QUO	2	0
-1	3	MUTUAL DESTRUCTION	3	-1
-2	4	SIDE B DOMINATES	1	1
SIDE A PREFERENCE ORDERING			SIDE B PREFERENCE ORDERING	

UTILITY DOMAIN A'S VIEW

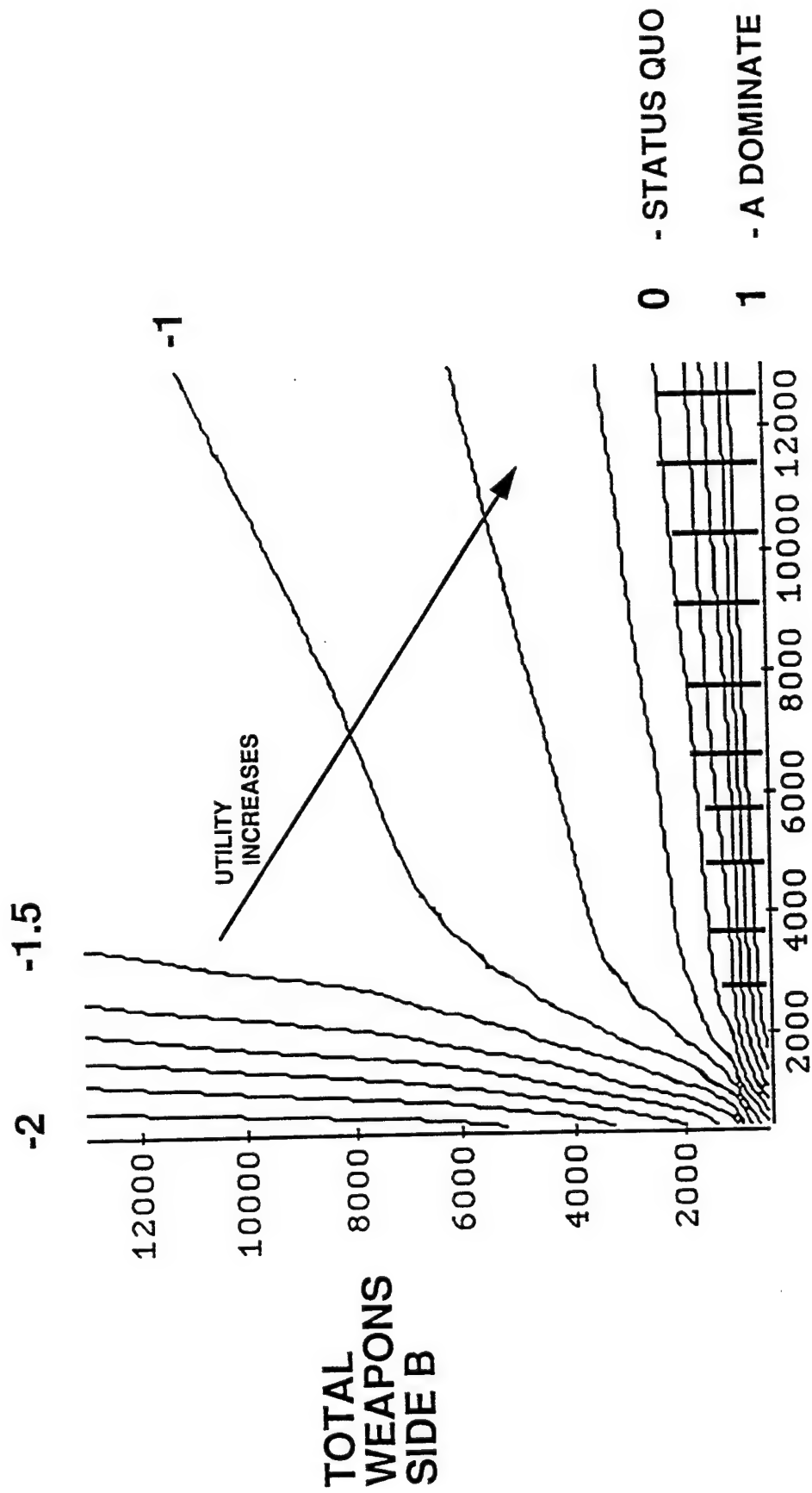
DETERRENCE
STABILITY
RISK



TOTAL WEAPONS SIDE A

**DETERRENCE
STABILITY
RISK**

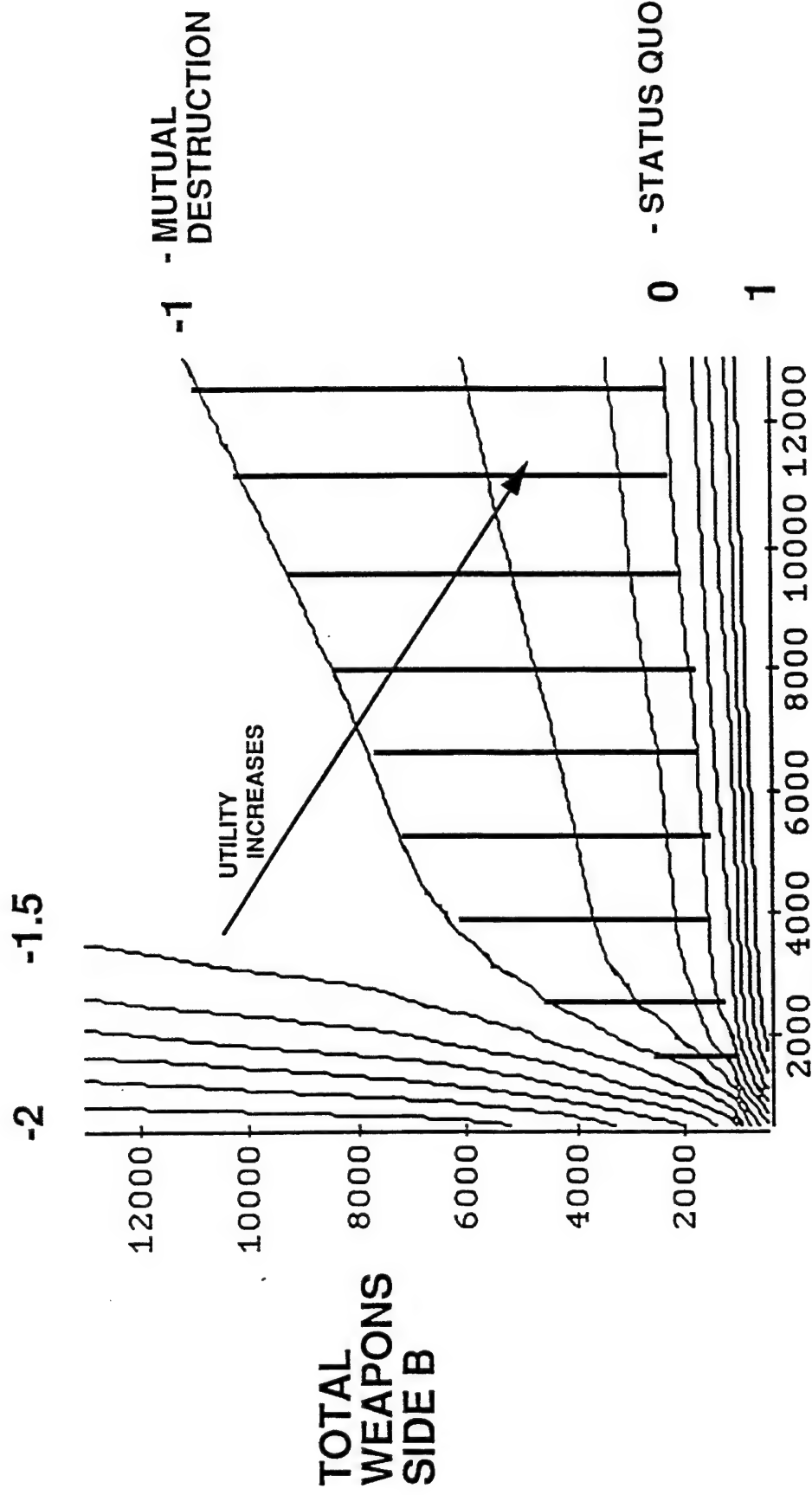
**UTILITY DOMAIN
A'S VIEW**



TOTAL WEAPONS SIDE A

UTILITY DOMAIN A's VIEW

DETERRENCE STABILITY RISK

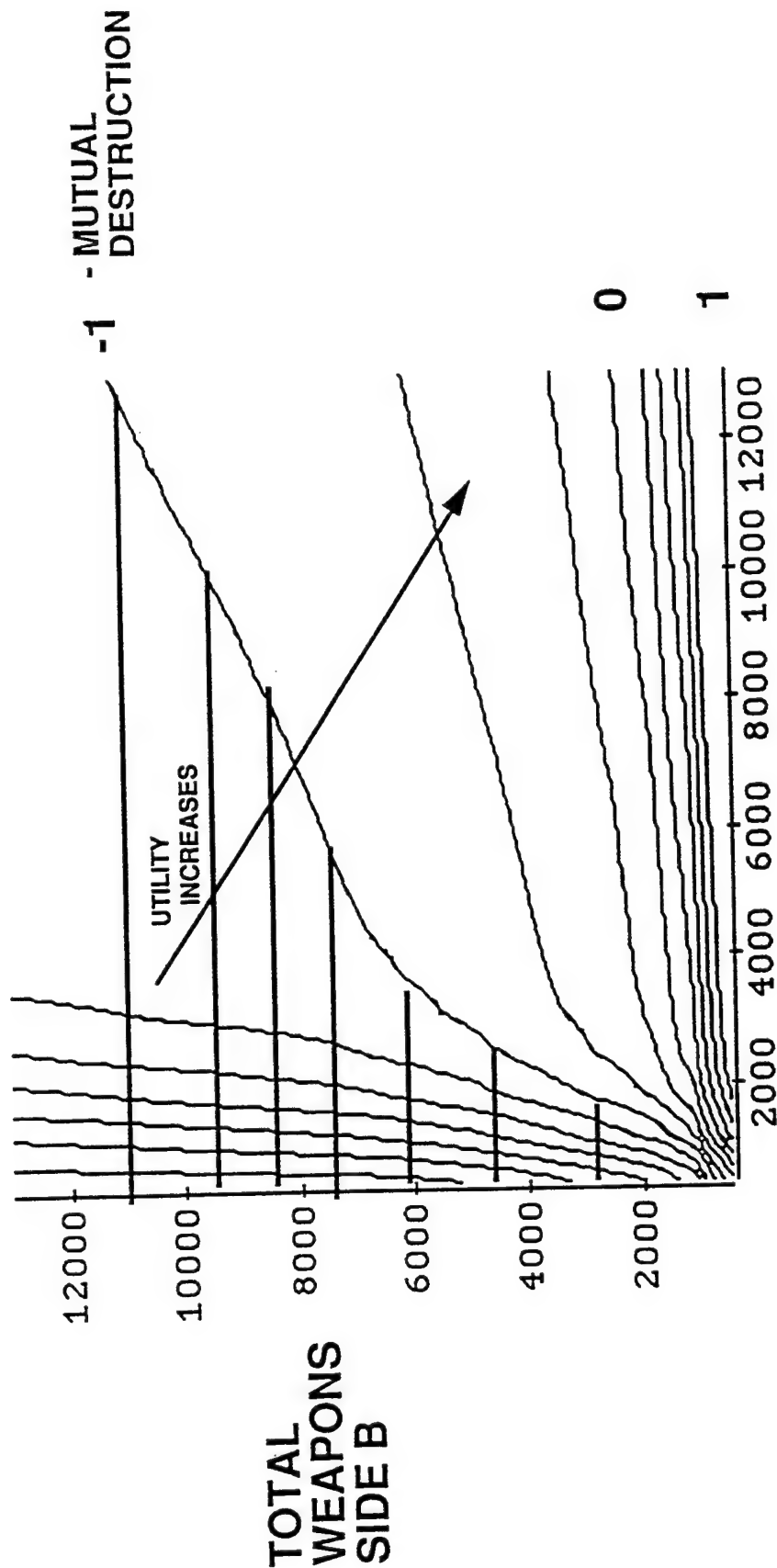


TOTAL WEAPONS SIDE A

DETERRENCE STABILITY RISK

UTILITY DOMAIN A'S VIEW

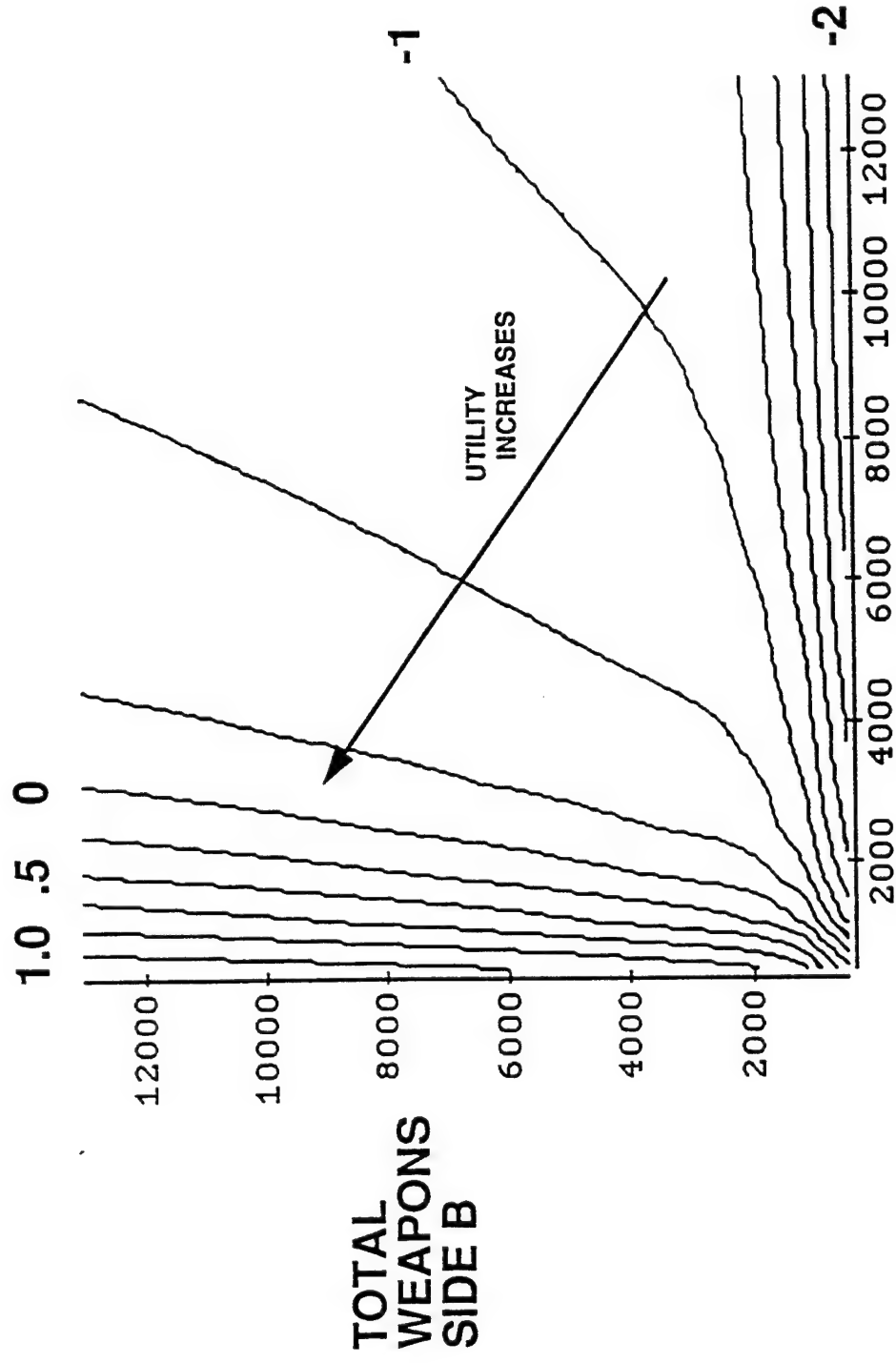
- B DOMINATES -2



TOTAL WEAPONS SIDE A

UTILITY DOMAIN B's VIEW

DETERRENCE
STABILITY
RISK



TOTAL WEAPONS SIDE A

DETERRENCE STABILITY RISK

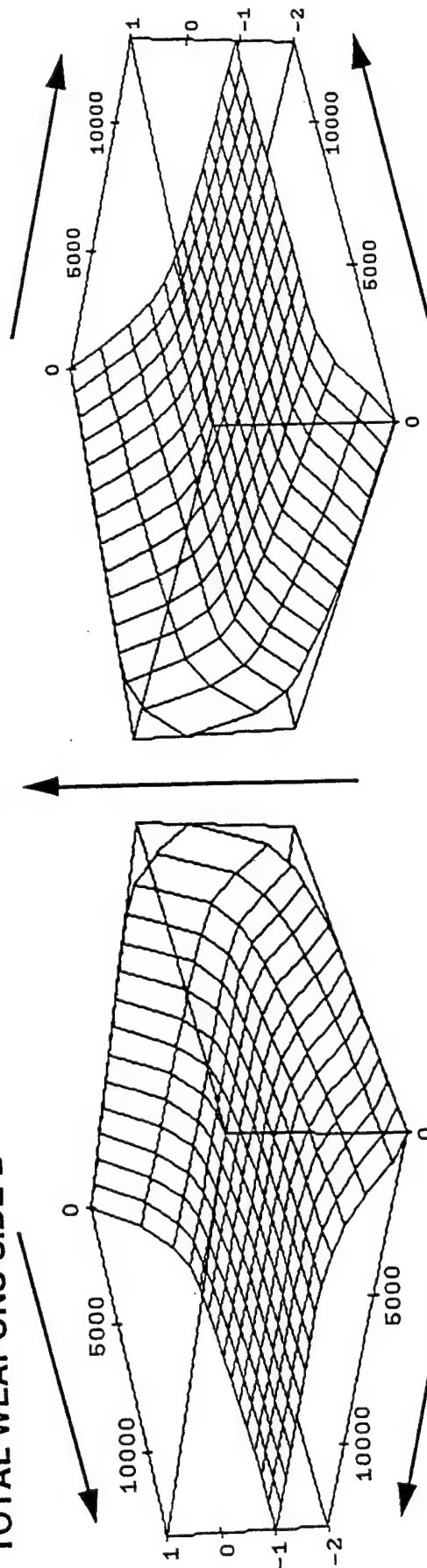
A's UTILITY

B's UTILITY

TOTAL WEAPONS SIDE B

TOTAL WEAPONS SIDE A

UTILITY



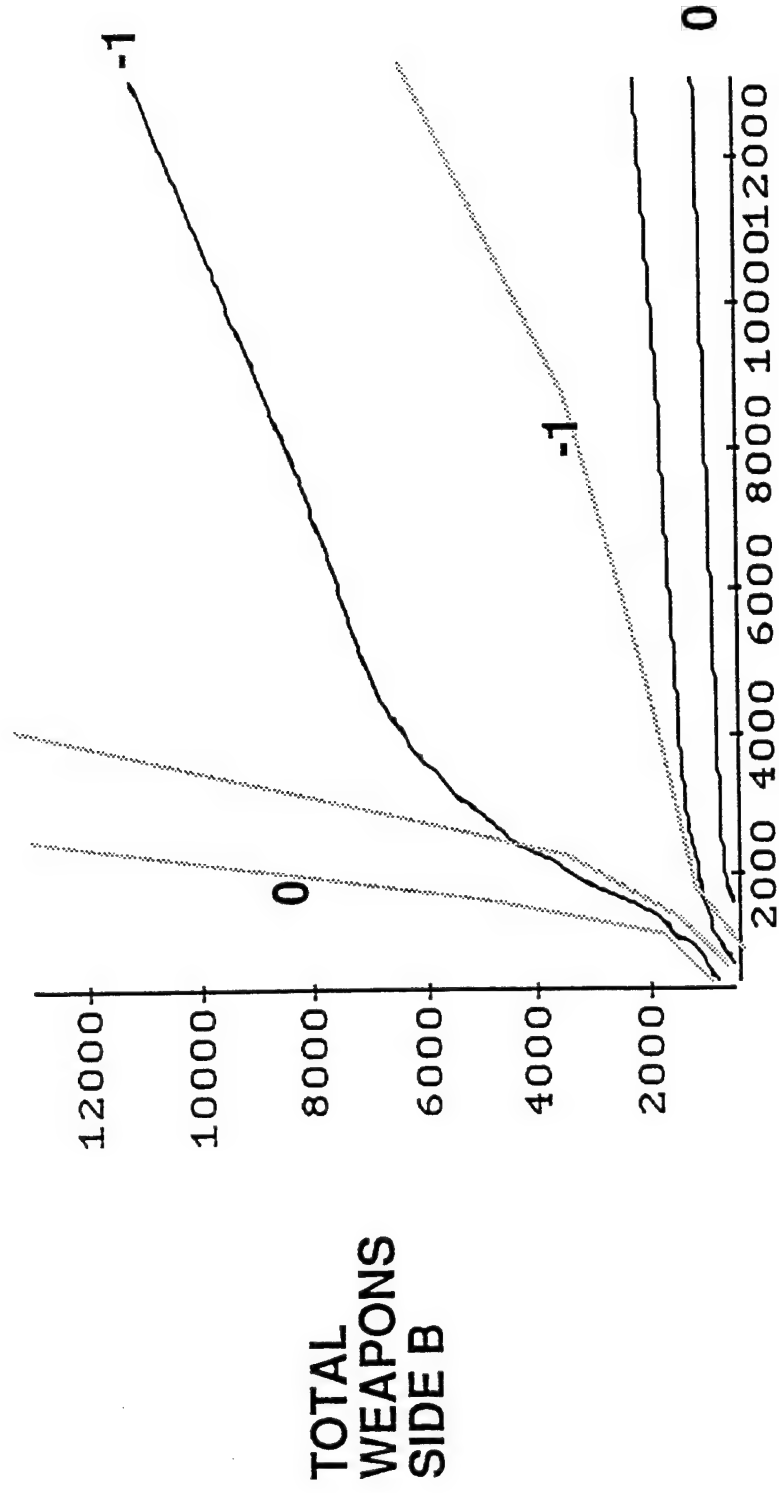
TOTAL WEAPONS SIDE A

TOTAL WEAPONS SIDE B

UTILITY DOMAIN

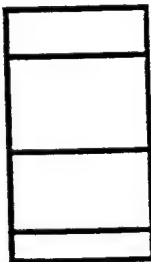


A



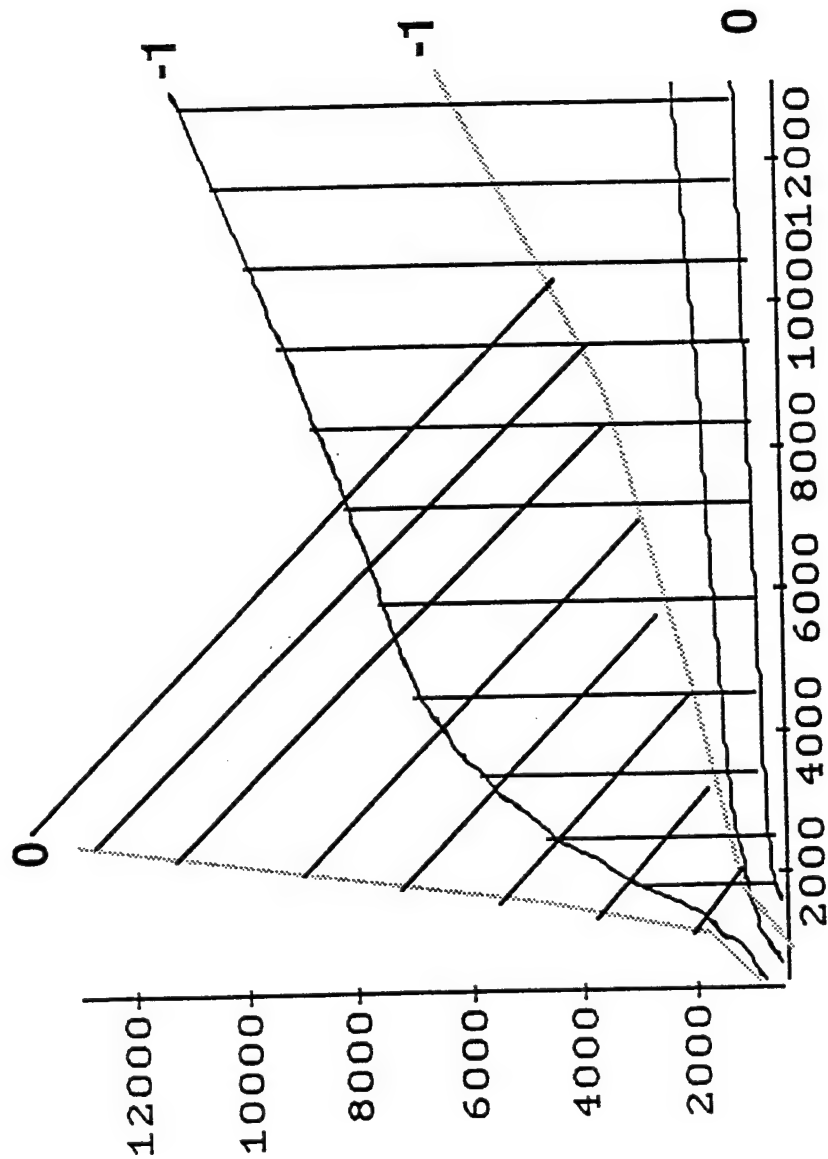
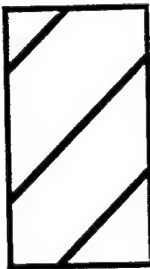
TOTAL WEAPONS SIDE A

A's VIEW THAT
NEITHER SIDE
CAN DOMINATE



DETERRENCE
STABILITY
RISK

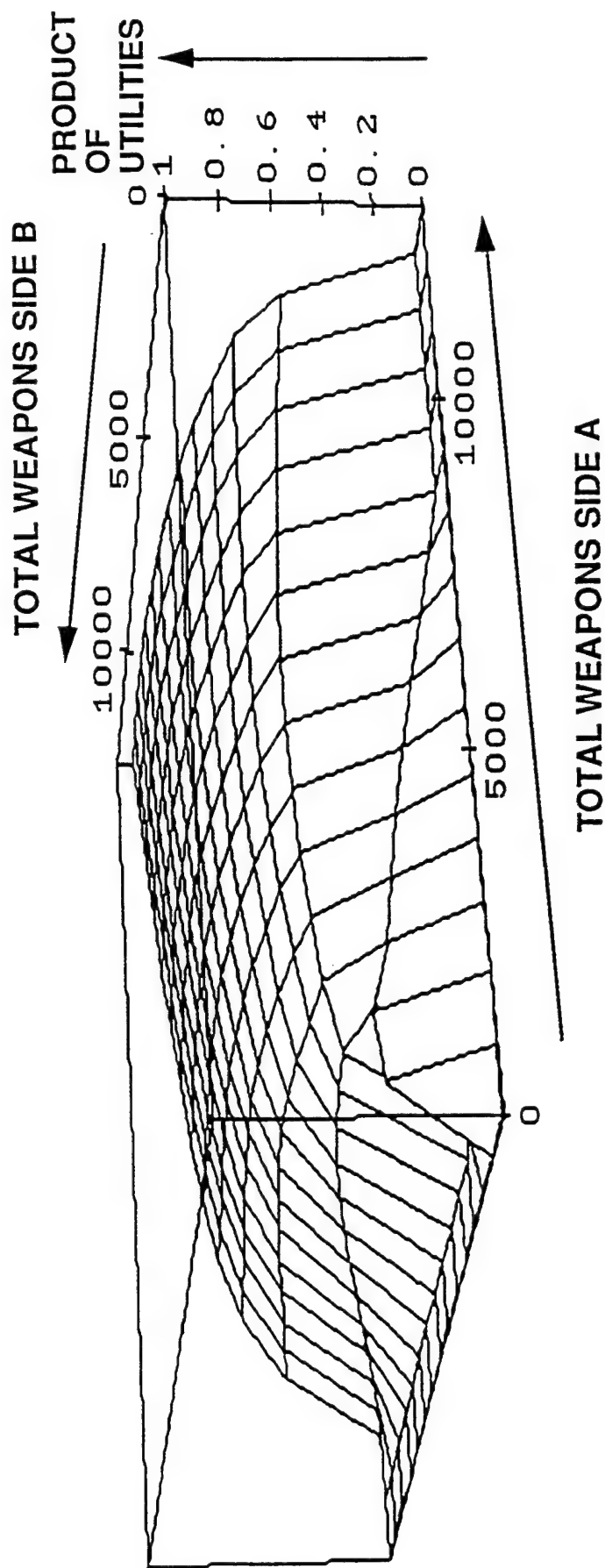
B's VIEW THAT
NEITHER SIDE
CAN DOMINATE



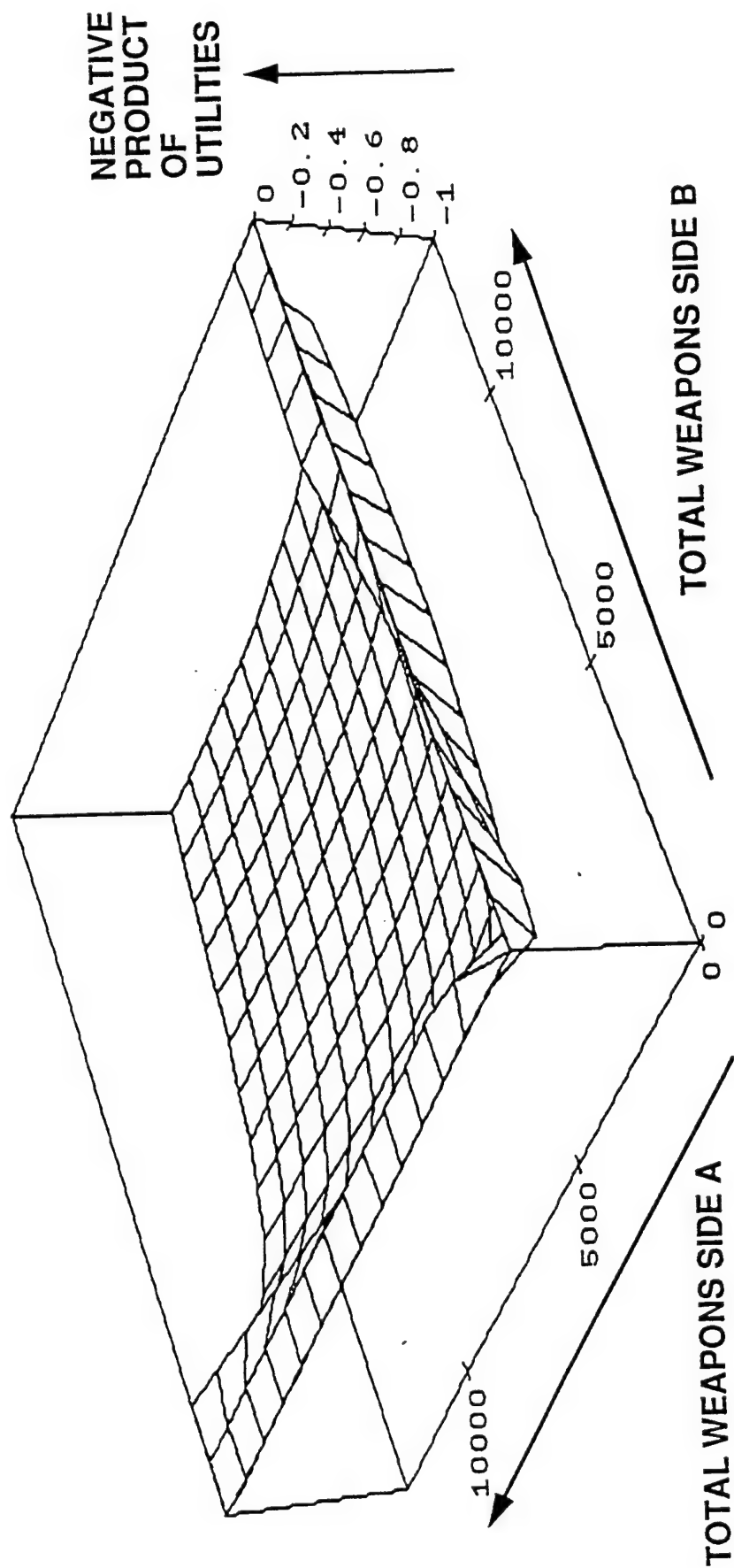
TOTAL
WEAPONS
SIDE B

TOTAL WEAPONS SIDE A

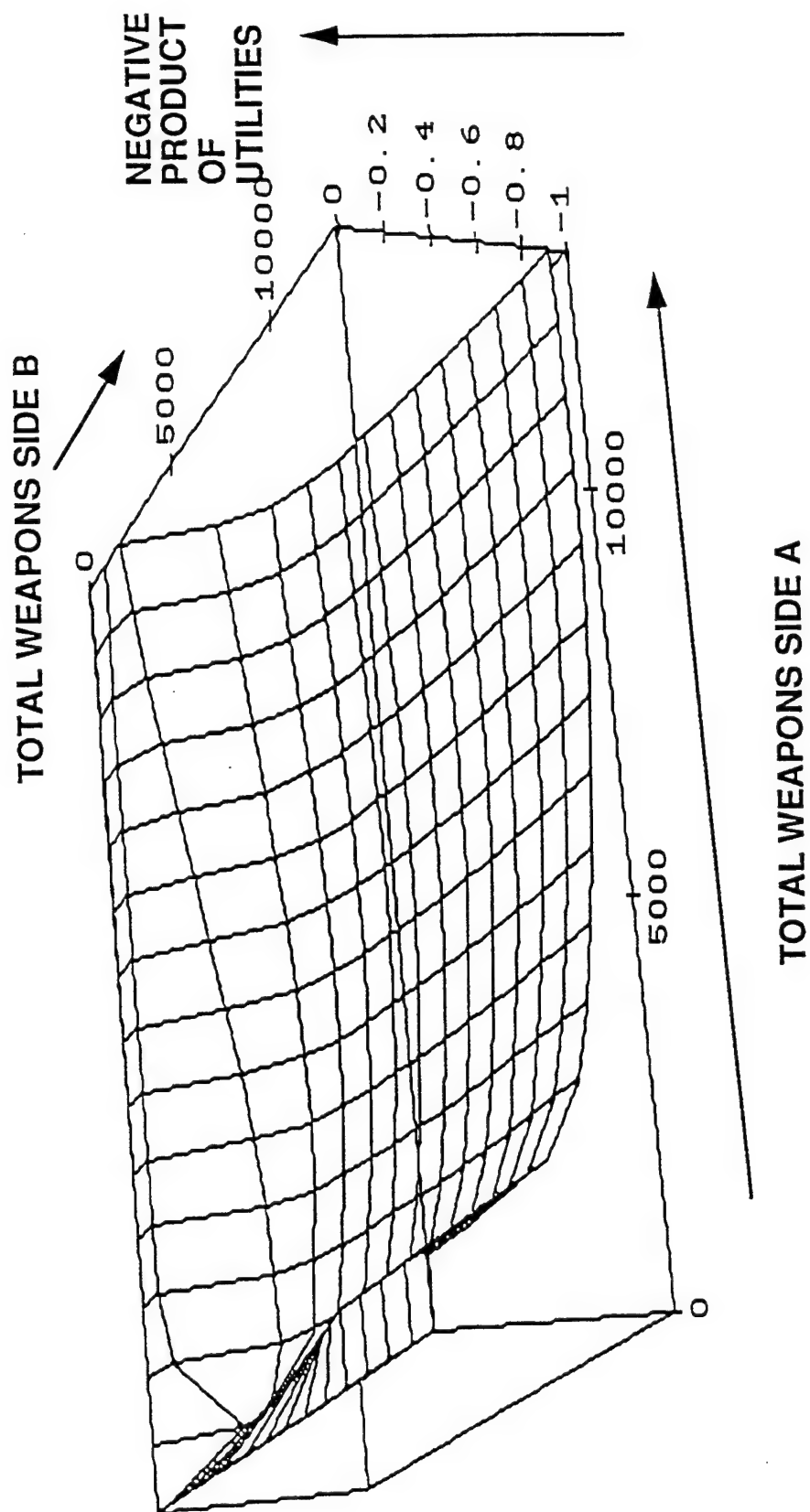
DETERRENCE STABILITY RISK

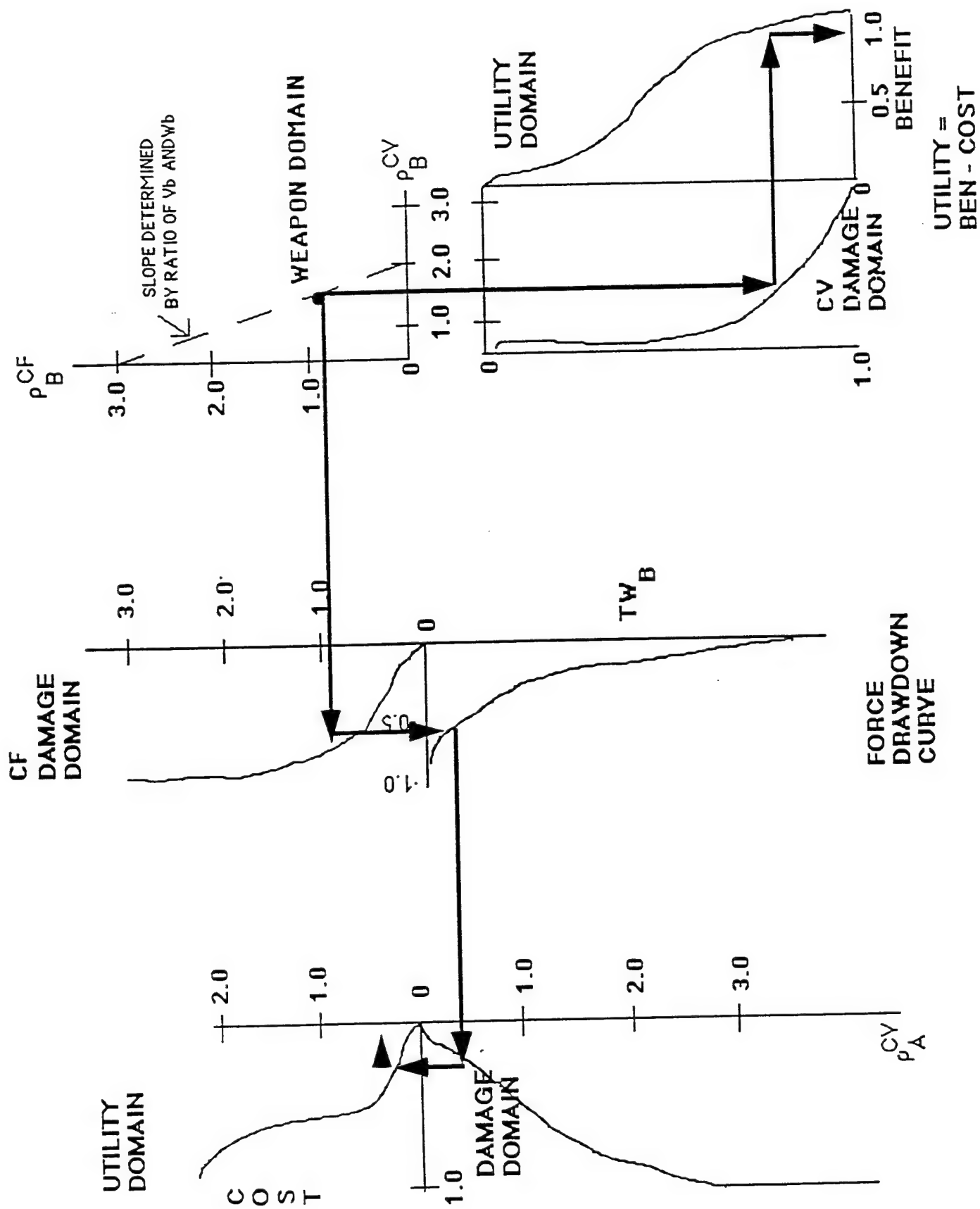


DETERRENCE STABILITY RISK



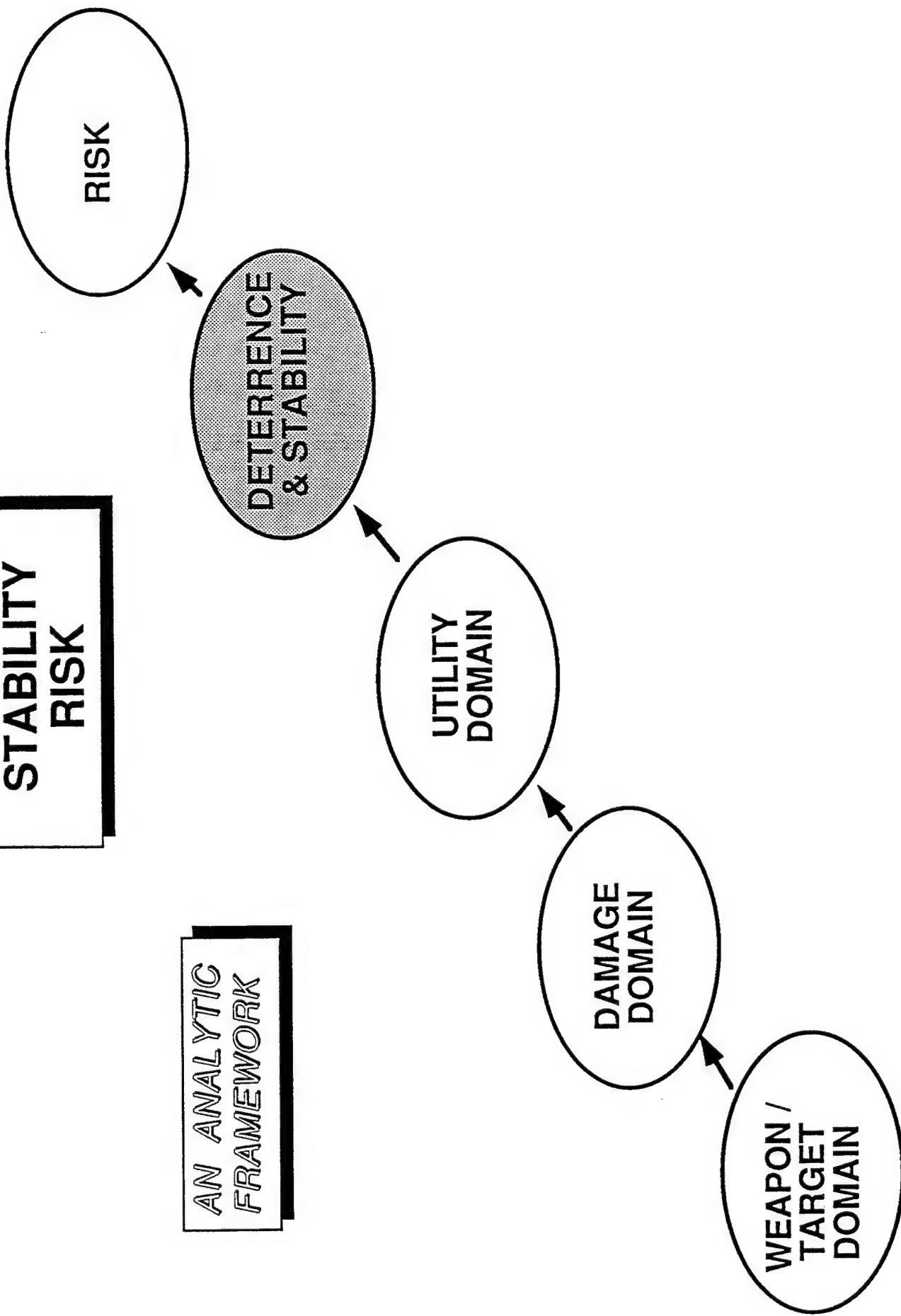
DETERRENCE STABILITY RISK





**DETERRENCE
STABILITY
RISK**

**AN ANALYTIC
FRAMEWORK**



DETERRENCE STABILITY RISK

STABILITY

DEFINITION: The condition that exists between opposing/competing parties when (1) both sides are deterred from initiating an attack on each other and (2) they both possess enough weapons so that the acquisition of additional weapons by either side negligibly increases/ decreases utility.

- (1) Deterrence is a necessary but not sufficient condition for stability
- (2) No incentive for an arms race.

DETERRENCE STABILITY RISK

(1) DETERRENCE

$$U_A < 0$$

$$U_B < 0$$

STABILITY

(2) ARMS RACE

$$\frac{\delta U_A}{\delta W_A} < < 1$$

$$\delta W_A \approx 0$$

$$\frac{\delta U_B}{\delta W_B} < < 1$$

$$\delta W_B \approx 0$$

UTILITY FOR A

+

-

N/A	UNILATERAL (UNSTABLE)
UNILATERAL (UNSTABLE)	MUTUAL (STABLE)

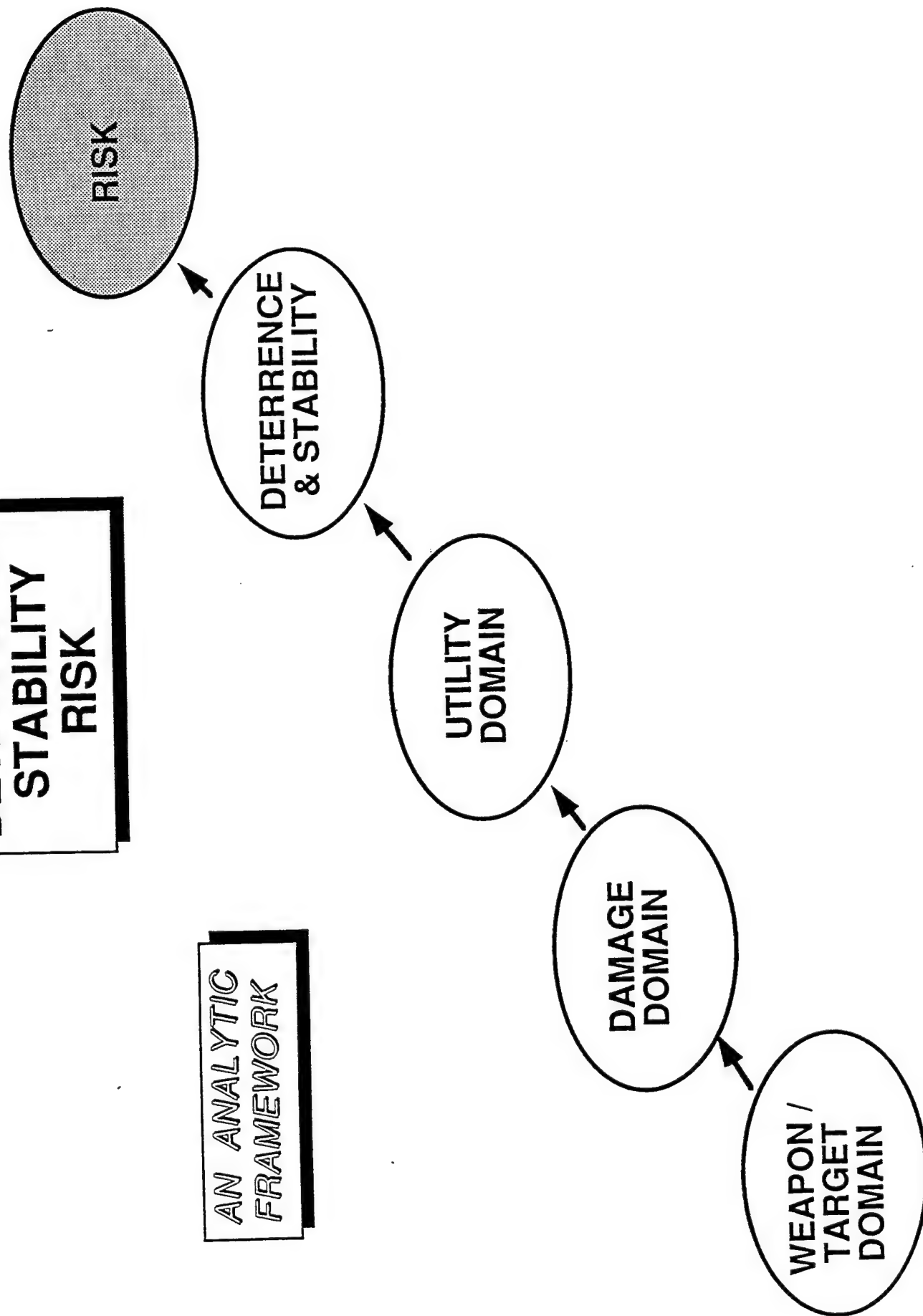
+

UTILITY
FOR B

-

**DETERRENCE
STABILITY
RISK**

**AN ANALYTIC
FRAMEWORK**



DETERRENCE STABILITY RISK

RISK

RISK = Expected consequences of an action in a situation

= Probability of the event * consequences of that action in the situation

= (Threat) * (Danger)

- * RISK THAT DETERRENCE FAILS**
- * RISK THAT SITUATIONS BECOME UNSTABLE**
- RISK OF ACCIDENTAL LAUNCH**
- RISK OF ESCALATION**
- RISK OF NOT MEETING SUFFICIENCY GOALS**

Appendix C6: Force Structure: Risk and Uncertainty Issue Category Group Report

Issue Category Leader:

John R. Statz, Jr.

Booz Allen & Hamilton

Participants:

Bart Emil Bennett	RAND
Paul S. Bloch	Naval Postgraduate School
Mary T. Bonnet	AFSAA/SAG
Alfred G. Brandstein	MCCDC
W. Peter Cherry	Vector Research Inc.
Terrence R. Colvin	Synergy, Inc.
Paul K. Davis	RAND
CAPT Robert W. Eberth	OPNAV N85X
John D. Elliott	US Army Concepts Analysis Agency
COL Raymond E. Franck, Jr.	USAFA/DFEG
W. Dean Free	CNO, N812D
Robert H. Halayko	The Joint Staff, J8
Nancy L. Hasbrouck	US Army Space & Strategic Defense Command
Margaret Daly Hayes	Evidence Based Research Inc.
MAJ Russell D. Hodgkins, Jr.	AFSAA/SAG
Gary E. Horne	MCCDC
LTC David W. Hutchison	OCSA-PAED
Nelson A. Jennings	Joint Warfare Analysis Center
LtCol Kent D. Lambert	US Army Research Institute
LtCol Jerry L. Levesque	HQ ACC/XP-SAS
David E. Mosher	Congressional Budget Office
Virginia L. Pierrot	Congressional Budget Office
Roy E. Rice	Teledyne Brown Engineering
LtCol James S. Shedden	ASC/XRE
Karen L. Somers	HQ ACC/XPSAS
Clayton J. Thomas	AFSAA/SAN
COL Bobby J. Thornburg	DACS-ZC-SSC
Capt Thomas J. Timmerman	AFSAA/SAGF
Barry D. Watts	Northop Grumman

Force Structure: Risk and Uncertainty Issue Category Group Report

3 October 1996

Introduction

Approximately 25 people signed up for the Category Group and 20 participated. The Group was divided into two Working Groups (WG) and each WG was assigned the task of reviewing a different concept for conducting Force Structure analysis. WG 1 reviewed a paper presented to the Category Group by Dr. Roy Rice and WG 2 reviewed a paper presented to the General Session by Dr. Paul Davis.

The two WG reviewed the two different approaches in different ways but were unanimous in their conclusion that either one was an improvement over an approach which looks at only a single scenario (e.g., 2 Major Regional Contingencies (2 MRC)). First order Measures of Effectiveness (MOE) were discussed and it was also generally agreed that the MOE proposed in each case were more useful than those currently used. The key attractive feature of each proposed approach was that each provided a framework that could be accepted by the analytic community as an initial standard for examining individual Force Structure capabilities.

The overall conclusion was that both approaches should be examined by decision makers and implemented. The advantage of the Rand approach is that it easily demonstrates the contribution of the "Now Regional Contingency" taskings to the National Military Strategy. The "Now RC" concept was introduced by MG Mark Hamilton, USA, Deputy Director, J8, in his earlier remarks to the General Session.

Force Structure: Risk and Uncertainty Category Group Agenda

Tuesday

1230-1245 Introduction (Room 2011)

1245-1315 Force Value Calculations (Roy Rice)

1315-1400 Adaptiveness in National Defense (Paul Davis - General Session)

1400-1445 The Art of MOE Development (Roy Rice - General Session)

1500 - 1530 Working Group Taskings (Room 2011)

1530 - 1730

Working Group 1 (Room 2011)

Discuss approaches to supporting decision makers' needs to evaluate force structure alternatives. Discuss the applicability of a Force Value-type calculator for identifying and integrating force structure requirements. Discuss ways to mitigate risk and uncertainty (what is it and how can FS integration analytic efforts deal with it?)

Working Group 2 (Room 4066)

Discuss approaches to supporting decision makers' needs to evaluate force structure alternatives. Discuss the applicability of a Rand-type approach for identifying and integrating force structure requirements. Discuss ways to mitigate risk and uncertainty (what is it and how can FS integration analytic efforts deal with it?)

Wednesday

0800 - 1000 Continued Discussion in Working Groups (Rooms 2011, 4066)

1000 - 1100 Working Group Reports to Category Group (Room 2011)

Recommended Approach(es)

Issues

Examples

etc.

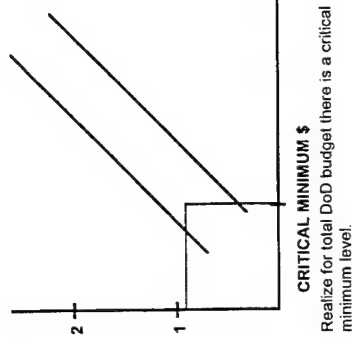
Force Structure: Risk and Uncertainty

Working Group 1

Mr Terry Colvin

METHOD (Iterative Process)

- Relate multiple levels of engagement, each at different levels of intensity (Rice's MOOTW, MRC categories) to help decision makers choose an affordable rationale.
- For each category, use range estimates to show risks, uncertainty, disagreements.
- Then look at force structure and try to clarify the range estimates.
- Look at validity of the "lesser included cases" (non-constraining).
- Begin with the now RC.



FORCE STRUCTURE: Risk and Uncertainty

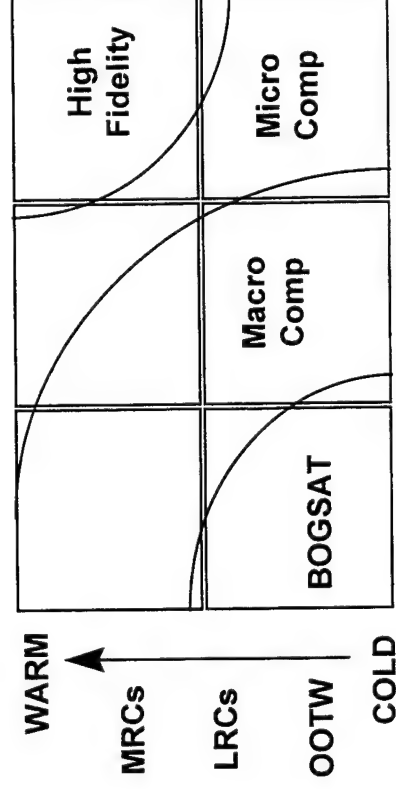
Proposed Methods of Structuring Analysis

	2 DAYS	2 WEEKS	2 MONTHS
WARM	Now RC (some services)	Now RC — given current overseas engagement, layout, forces needed Find short poles of tent Do macro computations Now + Then RC	Add detailed model runs to refine macro computations Rice & Davis tools look promising. (Rice tool for force mix needs to be extended to evaluate capability of force structure.)
	Use Service and JSTAFF models and studies for standard 2 MRCs and reasonable excursions; use Navy LRC work		
COLD	BOGSAT	Outline the problem. Develop a framework to address it. Start macro computations.	Do macro computations.

MOOTW is cold. Other Services need LRC work

Methods of Improving the Quality of Analysis Over Time

Point of Agreement:
Need to start building databases now for LRC and OOTW
(don't get caught "cold").



**Force Structure:
Risk and Uncertainty
Working Group 2 — The RAND Approach**

Dr Peter Cherry

Working Group 2 of the Force Structure: Risk and Uncertainty Category Group was charged with discussing approaches to supporting decision makers' needs to evaluate force structure alternatives in the context of the Rand approach described by Paul Davis in a briefing presented to the mini-symposium on 2 October and further detailed in the Rand Issue Paper: *Adaptiveness in National Defense: The Basis of a New Framework*. An overview of the working groups' deliberations, observations, and conclusions follows.

Before the working group focused its attention on the specifics of the RAND approach, it spent a significant portion of its time addressing the general issue of force structure in the QDR timeframe. While numerous points were raised, a few stood out. First, it was agreed that the process by which force structure alternatives are generated and evaluated is inherently more difficult than in the past. Geopolitical uncertainty and the demise of the Soviet Union have created a situation in which there no longer is a single point threat against which force structures can be evaluated, nor are the two MRCs a rational substitute for the Soviet Union. Forces are deployed on missions which were, at least, "lesser included" in past and current force structures, but which stress the size and readiness of the current force. The situation and the process are much messier.

As noted, the day-to-day deployments of unit and personnel to peacekeeping, peace enforcement, humanitarian assistance — OOTW — were not factored into the design objectives of the current force. However, such deployments are an obvious part of a strategy of engagement and enlargement and constitute a continuing mission for the armed forces. This being the case, the so-called "Now Regional Contingency" must be explicitly integrated into the force structuring process.

A related issue, since the demand for "Below the Line" forces in OOTW often is higher than that for their above the line counterparts, is that the emphasis on Below the Line forces must be increased. The distinction between above the line and below the line forces is becoming blurred — it will no longer suffice to generate support forces based on the above the line units required by an MRC. This observation also applies to past concepts of the "tooth-to-tail" ratio.

Finally, strategy will play a significant role in determining the value of one force structure alternative over another. It will be a critical input to the process. In particular, the working group, in discussing risk and threat, wondered if there was an "x" year rule for the emergence of a peer competitor, analogous to that used by the British between WW I and WW II. Such a rule would have a large impact, for example, on some of the structure/modernization trades mentioned in on-going discussions in the defense community.

Framing the Issue

- Process is much messier
- Must integrate "now RC"
- Must increase emphasis on below the line forces (distinction is becoming blurred)
- Strategy is critical input
 - Is there an "x" year rule for the emergence of a peer competitor?

The working group concluded that the concept of portfolio management in which investments are balanced among operational adaptiveness, environment shaping, and strategic adaptiveness had value. The concept inherently addresses geopolitical and military uncertainty and prods the analyst and decision maker to deal with these characteristics of the current planning environment. The concept further offers an alternative to the point threat/MRC based approach, and it expands scope to consider forward presence, as well as the contributions of small elements of force structure, e.g., exchange programs, liaison officers, etc. that contribute to environment shaping. It explicitly addresses tradeoffs between the near term and the far term.

Regardless of quantitative issues, the adaptive planning approach is important because it focuses attention on issues that are now critical (OOTW, for example, or the unpredictability of where forces might deploy, for how long, against what enemy) that in the past were handled as part of a large force designed to counter a super power in Central Europe.

Finally, the RAND approach provides a framework for attacking the force structure problem; a framework which will be logical whether or not quantitative, detailed evaluations and assessments are used. Indeed, it is the logical framework that may be its most appealing attribute.

Adaptive Force Planning

Concept of portfolio management has value:

- ✓ - Operational adaptiveness
- ✓ - Environment shaping
- ✓ - Strategic adaptiveness
- It focuses attention on issues previously treated as "lesser included." These issues are now more important
- It offers a framework that provides analytic rigor

The working group conducted a first order assessment of the RAND approach in terms of its immediate application and observed the following.

It is not clear how "mature" the approach is at this time in terms of data, algorithms, and even definitions. This should not detract from its adoption as a useful construct, but it may limit the scope of its application in the immediate future.

The process is not institutionalized in the sense that it is not in regular use in the defense analysis community other than at Rand. It needs to be brought out of the "research" mode and applied to a real problem. There will be some dissonance because it represents a radical shift from the point threat based approaches hitherto used.

The working group discussed MOEs at some length and concluded that operational MOEs and the tools to produce them are generally well in hand — the tool set is "dense." This is not the case for environmental shaping and even less the case for strategic adaptivity. Remedying this shortfall is not an insurmountable problem.

The conflict space and the algorithms for screening alternative structures exists in the Rand prototype. It is likely that additional definition of the conflict/scenario space will be required and additional screening algorithms needed. However, the working group believed that such screening could be performed at the "80% solution" level by subject matter experts if necessary.

Level of resolution was touched on during the working group's assessment. Clearly, the detail utilized (or desired) could be varied, but as noted, subject matter experts working at the level of divisions, wings, etc. could perform this step — finer levels of resolution could be accommodated and various models/algorithms applied to the screening process.

Adaptive Force Planning

- Not mature (?)
- Not "institutionalized"
 - Operational MOEs
 - Environment shaping MOEs
 - Strategic adaptiveness MOEs
- Conflict space
- Level of resolution

The working group did discuss the current approach and the tools available. It was observed that these constructs are to a large extent tied to precisely defined MRC threat/scenarios and system driven force structures. As such, they preclude innovative approaches. Given the significant differences in planning contexts between the past and the period envisioned by the QDR, they are not sufficient.

Application of the Rand concept will provide one solution to the existing analysis (and paradigm) shortfall. This is true regardless of whether the time available for analysis is two days, two weeks, or two months. The concept brings to the problem a framework which will lead to identifying and prioritizing key questions, ensuring that the analysis scope is as complete as possible and, in time, providing rational and explainable quantifiable and qualitative MOE.

- Current tool set precludes "Out-of-the-Box" solutions
- Contexts are different
- Rand concept provides a very useful framework, regardless of timeframe

CONCEPTUAL FRAMEWORK FOR QDR SUPPORT

by
Roy Rice

For
GRAM

Oct 1996

WCE/CART-15A/UM

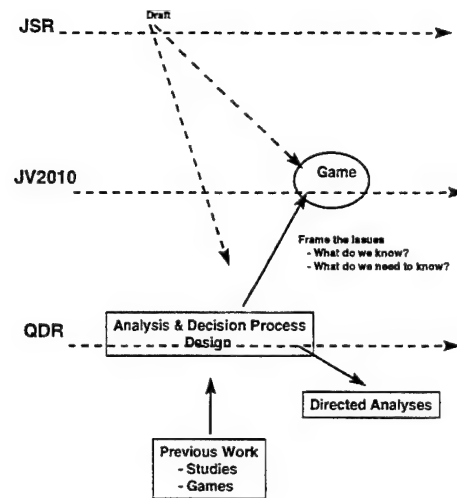
OUTLINE



- **Review the Bidding**
- **Complexity of the Problem**
- **Proposed Framework**
- **Implementation**

WCE/CART-15A/UM

PROPOSED FRAMEWORK

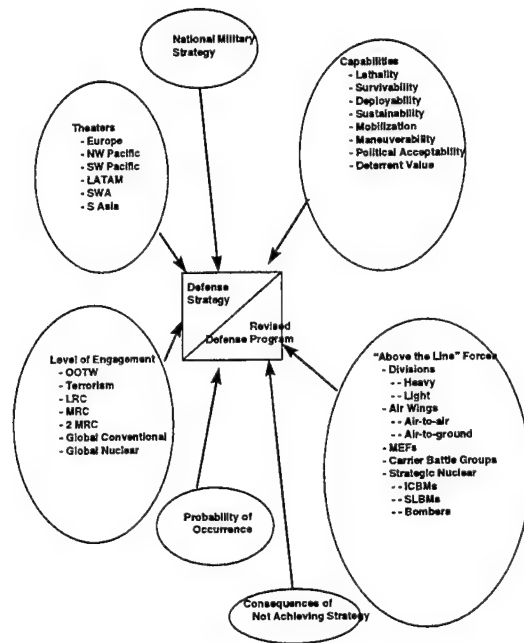


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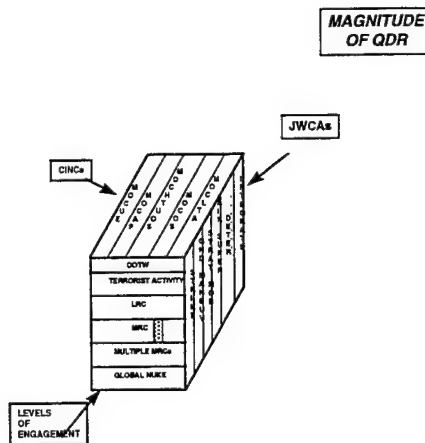
OUTLINE

- Review the Bidding
- ➡ • Complexity of the Problem
- Proposed Framework
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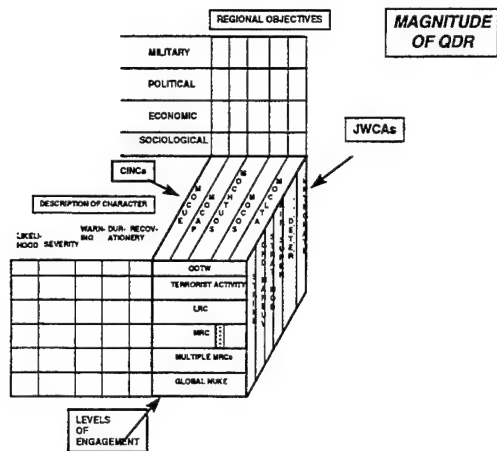
WCE/CAST - 13AUG04



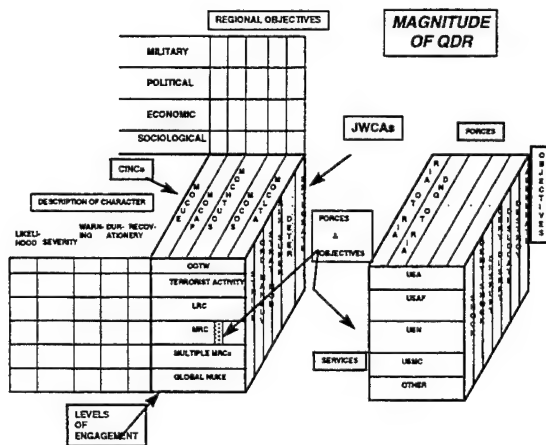
WCECAST - 13AUG96



WCECAST - 13AUG96



POWCAST-13A1006

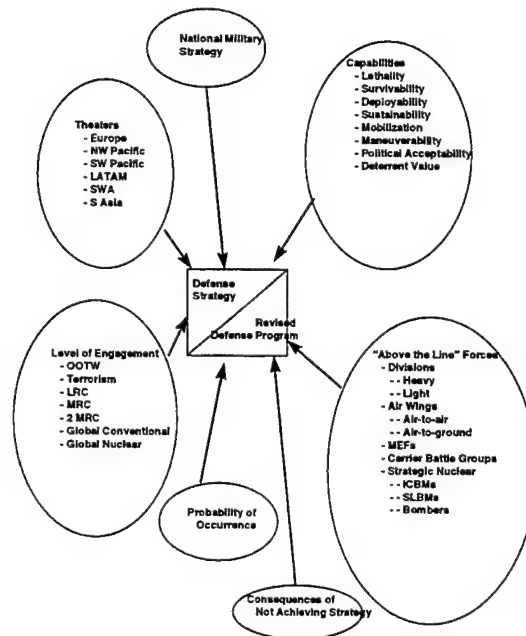


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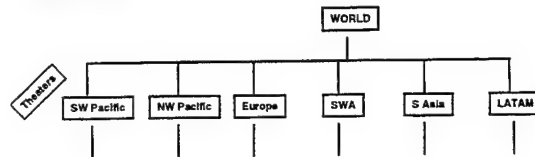
- Review the Bidding
- Complexity of the Problem
- Proposed Framework
- ➡ • Implementation

POC/CAST - 13AUG88



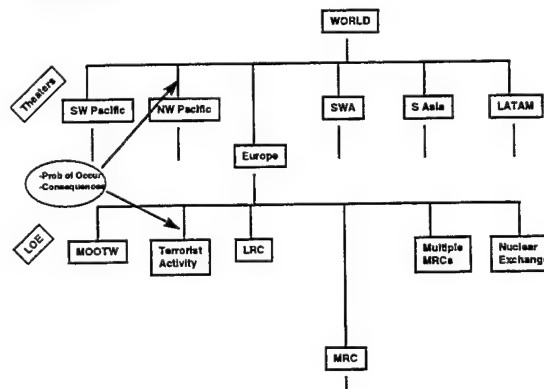
POC/CAST - 13AUG88

CONCEPTUAL
FRAMEWORK



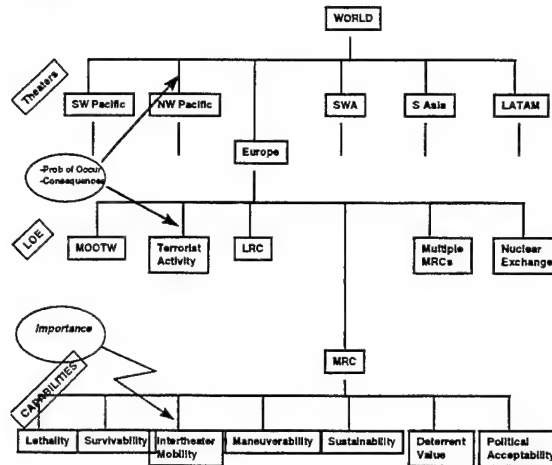
INCECAST - 13A1000

CONCEPTUAL
FRAMEWORK



INCECAST - 13A1000

CONCEPTUAL FRAMEWORK



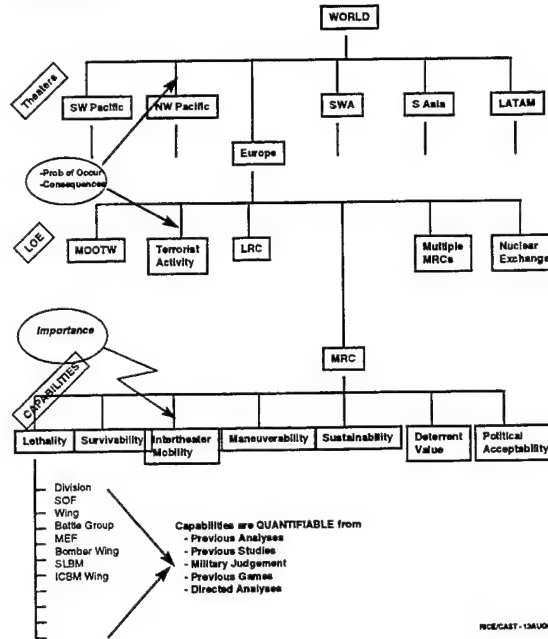
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DEFINITIONS

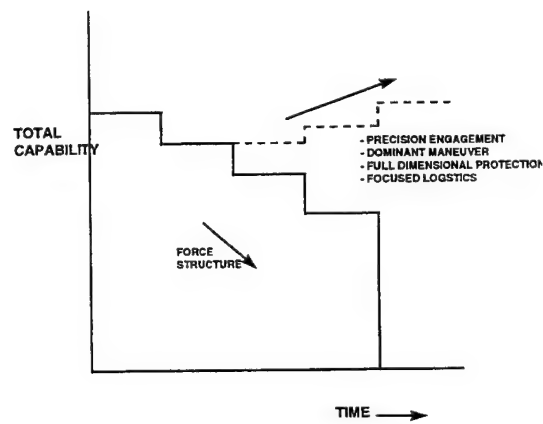
- **LETHALITY:** The inherent "damage/kill capability" a unit has against opposing weapons and/or targets. It's a function - $f(\text{enemy/targets/threat/unit firepower/threat density/environment/weather/terrain/suitability of weapons systems to targets})$
- **INTERTHEATER MOBILITY:** The speed, ease, and required resources it takes to deploy the force (port-to-port). It's a function - $f(\text{weight/passengers/size of equipment/distance/required carriers})$
- **MANEUVERABILITY:** The speed, ease, and required resources to maneuver in battle. It's a function - $f(\text{weight/size of unit/terrain/self-contained lift capability/battlefield density/threat})$
- **MOBILIZATION CAPABILITY:** The speed and ease by which it is ready to deploy (fort-to-port). It's a function - $f(\text{AC v RC/size/location/readiness of men \& material})$
- **SUSTAINABILITY:** The ease and required resources by which the unit is sustained. It's a function - $f(\text{POMCUS/WR/climate/terrain/intensity/consumption rate/spares availability/stockpiles \& lift requirements for the "stuff of sustainment"})$
- **DETERRENT VALUE:** How does the existence of this force contribute to deterring the enemy from entering this level of conflict? It's a function - $f(\text{force/threat/scenario/enemy "will"/enemy perception of US capability \& will to employ})$
- **POLITICAL ACCEPTABILITY:** The domestic and foreign political "acceptability" of introducing this type of unit. It's a function - $f(\text{political "damage" as a consequence weighed against expected "benefit"/suitability of "response-to-sh"})$

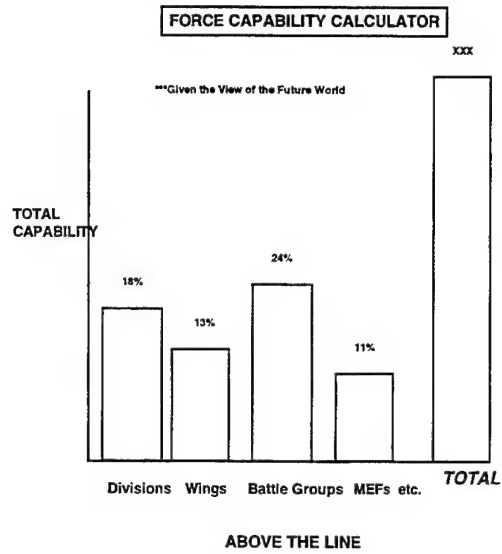
POC/CAST-13AL006

CONCEPTUAL FRAMEWORK

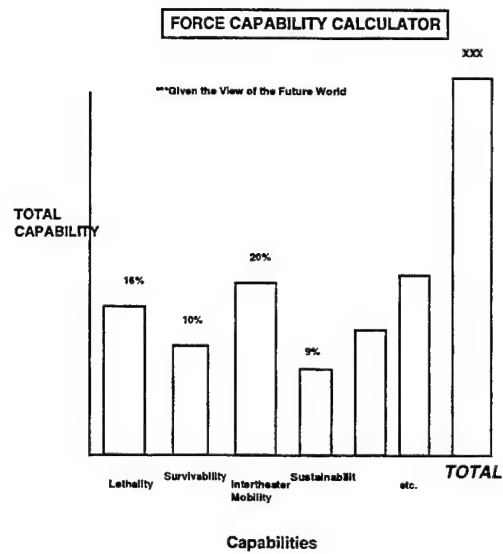


FORCE CAPABILITY CALCULATOR

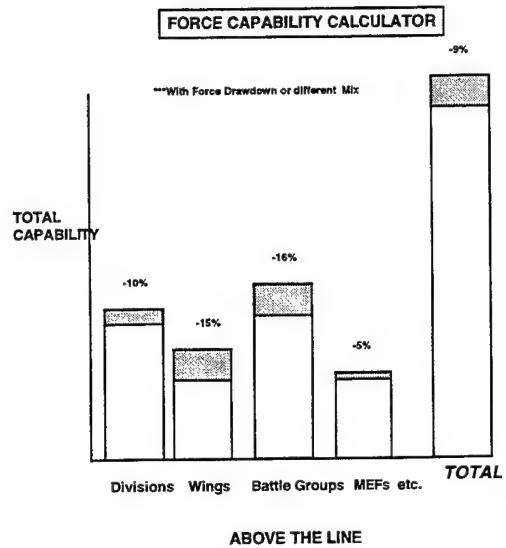




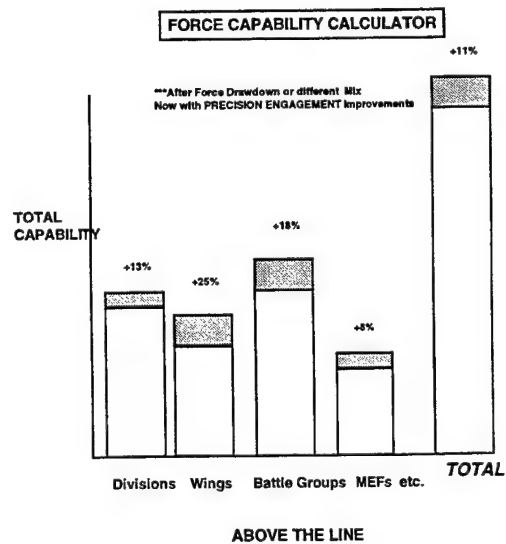
PRC/CAS7 - 13AUG96



PRC/CAS7 - 13AUG96

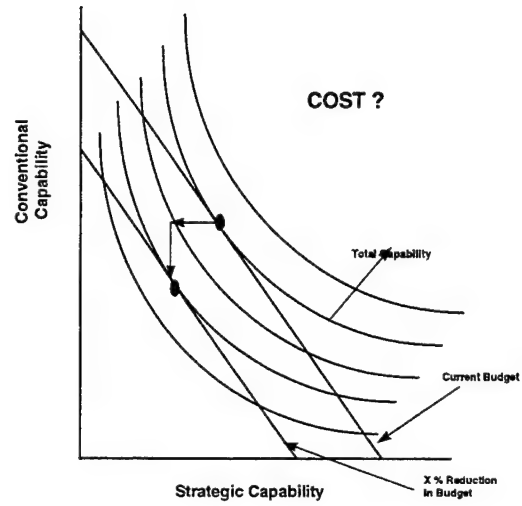


PRECEDENT - 13A1004



PRECEDENT - 13A1004

FORCE CAPABILITY CALCULATOR



FOCECAST - 15AUG98

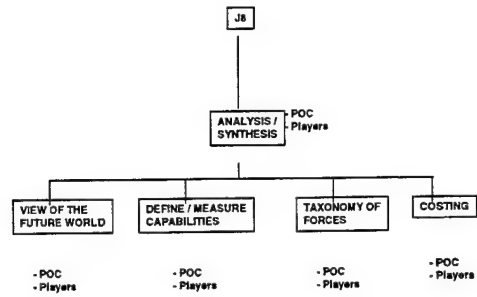
OUTLINE

- Review the Bidding
- Complexity of the Problem
- Proposed Framework
- Implementation



FOCECAST - 15AUG98

IMPLEMENTATION



RCECAST-13AU004

Appendix C7 – Infrastructure/Business Efficiencies/Right Sizing

Appendix C7: Infrastructure/Business Efficiencies/Right Sizing

Issue Category Leader:

Dan Barker

Office of Director, Program Analysis & Evaluation, OSD

Participants:

Bill Aldridge
Dave Cashbaugh
LtCol Mike Fuller
Fred Hartman
Dick Hayes
Jerry Kotchka
Hyder Lakhani
Jack Leather
Maj Roxann Oyler
Peter Pandolfini
Greg Parlier
Mike Parmentier
Sharon Pickup
LCDR Glenn Robillard
Dave Thompson
Maj Jim Taylor
Steve Woodall
Jim Worcester

SETA Corporation
The Joint Staff, J4
AFSAA/SAZ
Foxhall Group
Evidence Based Research Inc.
McDonnell Douglas Aerospace
US Army Research Institute
Defense Manpower Data Center
The Joint Staff, J4
JHU/APL
OCSA PA&E
ODUSD (Readiness)
US General Accounting Office
Naval Inventory Control Point
Naval Inventory Control Point
AFSAA/SAQ
Teledyne Brown Engineering
OPNAV

Introduction

The Department of Defense's (DoD's) infrastructure is approximately 45% of the directly appropriated budget or 55% of the total expenditure after revolving fund transfers associated with the Defense Business Operations Fund are taken into account. While the infrastructure has been reduced during the defense drawdown in line with the overall budget reduction, the pressure to restore investment funding to support force structure recapitalization without adversely impacting readiness directs an increased scrutiny to find further savings. However, this is not going to be trivial. Four contentious Base Realignment

and Closure (BRAC) rounds will ultimately yield approximately \$6B in savings. Further, some areas of the infrastructure have been stressed in recent budgets to fund near term readiness activities or to support force deployments. The consequence is that only a disciplined approach to reducing the infrastructure will yield a tractable plan—a plan that 1.) incorporates the necessary support to the forces in times of peace and surge, 2.) explicitly factors the internal and external barriers to change, and 3.) gathers the savings associated with reduced capacity or increased efficiency. The issue category group determined that two successive questions need to be answered:

What infrastructure is needed to support the DoD? {capacity}

What is the most cost-effective way to provide it? {efficiency}

These questions imply a constructive, baseline approach to sizing the infrastructure instead of conducting analysis on the margin. Because the infrastructure can be partitioned, the baseline approach can be applied to a portion of the infrastructure that could lead to a marginal change in the infrastructure. Marginal analysis focuses on incremental changes in a program to fine tune an infrastructure area, whereas baseline analysis attempts to derive the “desired” infrastructure. The difference between the current program and the “desired” program is then measured to provide insights on how the program should be changed as resources allow.

Disciplined Thinking

Within an infrastructure area, three questions need to be answered, in succession:

- 1.) What needs to be done, and why should it be done?
- 2.) How much is required?
- 3.) How should it be accomplished?

In attempting to answer the question of what needs to be done, the risk is that the current program will define the response. Everything in the current infrastructure program should be challenged. For instance, anyone familiar with the defense program can recite portions that have at one time or another been identified, by one group or another, as non-traditional military missions. There are also infrastructure activities in the current program that may not be part of DoD’s core functions. Junior Reserve

Officer Training Corps in the high schools is one illustration that members of the issue category group identified. It is recognized that everything in the defense program is there for a reason. The fact that Congress has appropriated funds for these activities indicates that there is a purpose and a constituency associated with them. The purpose of this question is to ensure that a given infrastructure area’s mission continues to be validated in the current defense context based on the current or future national military strategy, political will, and anticipated budget levels. The question of what needs to be done should look for areas of support that the national military strategy may require that are not within the current program. For instance, a strategy of enlargement and containment may suggest a “nation building” capability that would be considered an identified portion of the infrastructure—NATO infrastructure is currently accounted for within the DoD program as part of the Force Management segment of the infrastructure taxonomy. Perhaps it is time to build a “four pillars” type of view for the infrastructure that relates the infrastructure to the national military strategy by way of accepted capability categorizations or mission areas.

The maximum potential to affect the infrastructure is to control the decisions on what the DoD infrastructure should include. Once a specified infrastructure capability is adopted as part of the DoD mission, the next question is how much of the capability is needed? This must be expressed as short and long term goals in the context of peacetime requirements and under surge conditions. Many areas of the infrastructure are amenable to variable capacities that can be matched to force structures or adjusted through iteration to appropriate levels. A few areas are more binary than variable, a

minimum implementation level must exist to satisfy the requirement. However, all areas of the infrastructure need to have standards by which their adequacy can be evaluated. These standards will help to answer the question of how much is needed to be effective to be determine if DoD has the needed capacity or is in an overcapacity condition. Furthermore, these standards need to be consistently applied across the department. When various activities establish varying standards of capacity for similar activities, the obvious question is what parameter(s) explains the differences? The process of examining differences in standards may illuminate areas in which the DoD infrastructure warrant change.

Once it is determined what capabilities are needed in the infrastructure, and how much of those capabilities are required, the remaining question is one of efficiency—how should DoD accomplish the infrastructure mission? It is understood that determining how an infrastructure capability will be managed must consider the political environment and the risks associated with a failure in delivering an infrastructure capability within the context of the national military strategy. However, it is suggested that efficiency concerns should be the basis for any initial ranking that allocates an infrastructure capability among the military services, government agencies—both in defense and in other executive departments, and the private sector—both outsourcing and privatization. Once the efficiencies are understood, then the political environment and risks to national security can be considered. Within this context, the measures of effectiveness (MOEs) that may be considered are cost savings, impact on readiness rates, the time to recapitalize, and the ability to free up military endstrength from the infrastructure

to return them to the forces. Obviously, these MOEs are not necessarily in priority order. Overall reductions in military endstrength are considered as part of the cost savings. While costs may not be minimized when military endstrength is shifted to the forces, retaining the endstrength may be appropriate in a larger context than the infrastructure.

Several challenges exist to implementing an analytic formulation of the infrastructure. Cost models will need to be specific for each infrastructure capability even though their basic structure will be built on personnel costs, equipment costs, and real property costs. The Achilles heal of analysis is typically difficulties in the data and the infrastructure area is no exception. Data in this area is as different as the number of constituencies that must be considered by the analysis. Data standardization has not caught up with the infrastructure yet. This is especially problematic to analysis in this area because of the number of activities that comprise the infrastructure. The saving grace to the data problem is that infrastructure analyses typically include the affected activities as participants since their senior leadership is part of the DoD corporate decision making process.

Several corollary issues must be examined during analyses of the infrastructure. Infrastructure changes must be considered in the context of other changes within DoD to its mission and force structure. Typically, infrastructure reductions must lag force structure reductions to preclude a hollow force. This is one of the points that makes the recent DoD accomplishment of drawing down infrastructure in line with the budget a true success story. It was done alongside the force structure drawdown. Future infrastructure drawdown will need to allow continual support to the force structure.

This is especially true if infrastructure is re-engineered since economies may preclude an overlap in capabilities. Re-engineering infrastructure areas needs to be considered after analysis determines if technology or other applications of capital can be used to reduce the infrastructure. This is what happened as part of the civilian personnel regionalization decision process.

Management of the infrastructure is fragmented within OSD and the Military Departments. While this complicates the internal analysis and decision process, several external impediments exist to reducing the infrastructure further: the BRAC legislation has expired, the 60:40 allocation for depot maintenance between organic DoD activities and contractors limits further outsourcing, Davis-Bacon inflates labor rates, etc. Other impediments, such as OMB Circular A-76 which regulates the competition of outsourcing, slow the rate at which the infrastructure can be reduced. The Quadrennial Defense Review (QDR) represents an opportunity to articulate a cogent explanation of how infrastructure costs could change with legislative relief. The infrastructure also represents an area

where incentives to support reductions are thought to be useful. To this end, OSD assured the services that privatization and outsourcing savings could be applied to modernization without affecting their budget allocation. The service responses varied a great deal.

The Infrastructure Issue category group tried to assess the potential for quick reaction analysis within the overall framework for the symposium. Examining how infrastructure issues have been assessed in the past as a response to budget or program adjustments is a "good" first step. The overall impression is that getting access to data will be a significant policy issue. For instance, prior BRAC databases could provide a wealth of information on installations that were not included in previous BRAC rounds. In addition, the group brainstormed on a list of illustrative infrastructure areas that might be useful to analyze and then tried to develop a metric for evaluating the utility of such analysis. These two charts are presented without defense because they are essentially data free, not the preferred situation for any analyst to find themselves.

Illustrative Infrastructure Issues

- | | |
|--|--|
| ✍ Civilianize/outsource medical area more | ✍ Outsource significant portions of OBOS personnel |
| ✍ Explore joint recruiting concepts | ✍ Privatize and Outsource QOL |
| ✍ Privatize commissaries/exchanges | ✍ Consolidate ranges: training, test, and evaluation |
| ✍ Consolidate academies | ✍ Change the way ranges are resourced |
| ✍ Privatize DoDEA | ✍ Capitalize all transportation within TRANSCOM |
| ✍ Outsource institutional training | ✍ Explore joint ROTC concepts |
| ✍ Explore joint depot maintenance | ✍ Reductions in management headquarters |
| ✍ Reduce depot maintenance capacity | |
| ✍ Outsource more of the S&T | |
| ✍ Outsource finance completely, use audits | |

Infrastructure Quick Reaction Analysis Assessment

If Base Is		2 Days	2 Weeks	2 Months
Warm	Precedents exist with completed studies. BRAC data accessibility is an issue. Privatization and outsourcing analysis has been done.	Most of these prior efforts have taken the low hanging fruit. Two weeks would allow updating previous insights. Issue papers from previous program reviews document alternatives that may deserve reformulation.	Some studies are ongoing that may yield results that are useful in this timeframe.	
	Identify precedents and previous positions from prior work-- successes and failures	Work with services to identify where opportunities exist Start to develop goals and strategies	Refine the 2 week answer	
Cold				

Appendix D1 – General Chair Observations
Dr. Jacqueline Henningsen, OSD/PA&E

Concluding Remarks: General Chair Observations

Closing Observations. The issue category leaders and participants and the synthesis group did an outstanding job of considering quick response requirements and methodologies in light of the QDR. In this mini-symposium, participants focused on the analytic processes and methodologies required to gain a first order understanding of several QDR related issue categories. The organizing concept for their explorations was the matrix that compared the availability and significance of a cold versus warm base for analysis given that an analysis was required in two days, two weeks, or two months. In the reports found in the Appendix, this matrix is discussed specifically as it relates to individual issue categories. In addition, some overarching results emerge when we look at the current debates from the matrix perspective.

The synthesis panel report summarizes some of these cross-cutting insights including the general point that the warmer the base the more readily and competently quick response analysis can be accomplished. Prior to the mini-symposium, the idea of a warm base primarily focused on tools and data bases. Discussions with many participants during the mini-symposium about what their organizations were doing to prepare for the QDR pointed out that the warm base/cold base concept needs to be further sub-divided. For quality analysis in support of efforts like the

QDR, the intellectual/analytical base and the organizational base must also be kept warm.

In terms of the intellectual/analytical base, we have tended to assume in the last several years that investment in research means investment in technology demonstrations and distributed simulation enhancers. In addition we have tended to equate the capability to use spreadsheets and computer models with intellectual/analytical capability. Careful consideration of the requirements for warming up the intellectual/analytical base will focus on how we educate analysts, how we upgrade the skills of current analysts, and how we invest in research. In the latter area, an important follow-up to this mini-symposium would be the development of a list of research areas. The length of each session provided little time to explore the identification of these topics, but participants and those who review the reports are encouraged to consider the importance of this activity.

Participants were even more emphatic that the organizational base should be kept warm to insure that quick response analysis is also quality analysis. Many attendees suggested that the tendency to operate in stovepipes which has been so often decried in models is even more pronounced in

preparations for major analysis. Current leadership models tend to focus on the importance of *connectedness*. A related term, particularly of interest in venture capital circles, is the Japanese term *kereitsu* which is used to describe an interlinking group of organizations that share common information, data sources, and goals. The focus of venture capital use of *kereitsu* is on building industries, not just companies. This is a trend that the Department has paralleled to some extent in recent collaborative analyses for weapons mix studies.

Extending these concepts to a major activity like the QDR requires a change from the norm. Rather than a crash program every four years, participants and the synthesis group suggest we should consider how to build a connected structure that keeps the whole organizational base warm. The synthesis group suggested a contract between analysts and consumers of analysis that acknowledges the steps each group can take to enrich the QDR process. Other participants suggested that a designed network be laid under existing structures of the Planning, Programming, and Budgeting system. The Defense Planning Guidance, the Chairman's Program Assessment, the CINC's Integrated Priority List, and the Program Objective Memoranda were all mentioned as having the potential to contribute to the maintenance of this warm base.

Keeping the base warm with connectedness doesn't mean that components can't defend their

interests. In fact, as RAND's Paul Davis and David Chu have both pointed out, competition is worth encouraging, but at an elevated level that builds on a common foundation. By maintaining warm data bases, methodologies, and analysts' preparedness; adding an increased investment in intellectual/analytical research that provides insights into difficult questions; and by designing analyses that leverage the benefits of connectedness (and of competition) decision makers can be supported with quality quick response analyses.

Appendix D2 --Observations for MORS
Clayton J. Thomas, AFSAA/SAN

SUMMARY OF SERENDIPITOUS INSIGHTS

Introduction. Where the Insights Originated: The MORS Office provided a list of potential participants in the Quick Reaction Analysis Methodology (QRAM) meeting. Selecting some whose e-mail address I had--and largely avoiding those already fully occupied in QRAM execution--I sent messages asking those participants to jot down before leaving the meeting any comments, concerns, frustrations, excitement, or just general insights that QRAM had triggered. In prior special MORS meetings, I had observed participants making insightful comments and/or raising important and provocative issues that were not recorded, or at least not reflected in the meeting proceedings, because they didn't fit the agenda of the meeting or the format of its working groups. It seemed worthwhile to try to save some of these.

The response was very satisfying. Several of my correspondents who were unable to attend the meeting sent comments before the meeting. Some dozen others who did make the meeting also gave generously of their time and thoughts. All of their comments are stimulating and useful. Some directly address the current Quadrennial Defense Review (QDR) or the QDR process, some identify or emphasize important and "eternal" analytic truths, some warn of folklore elements that too often pass for analytic truths, and others give useful general principles for planning and conducting MORS special meetings with some specific comments on QRAM. The following summary of insights uses those categories in its organization.

The QDR Process. The timing of the QRAM meeting gave it a fortunate opportunity to contribute suggestions of potential help to the current QDR, which is not yet fully defined (or at least not fully advertised throughout the analytic community). The participation of analysts and organizational elements in supporting studies, and the tools they will use, are still being determined. Moreover, it is anticipated that many of the studies will require the quick response with which QRAM is particularly concerned.

Past experience of some who have experience in institutions dedicated to quick response analysis (QRA) suggests that much can be done in the fall of 1996 to prepare for intensive work in the current QDR in the months ahead:

Find a basis for analysis beyond the SWA and NEA scenarios. Start thinking hard about current capability versus modernization. In aircraft, and maybe other areas, ageout will become increasingly critical. Taking the list of major issues facing QDR, work for the next few months to build an analysis infrastructure (analysts, data, and models) to be ready for specific questions. Framing questions well enables some use of large detailed models to construct effective quick response "what if" tools via techniques such as response surface methodology and the Army CAA's "Value Added Methodology."

There are several items that challenge current force structure analysis generally, and QDR in particular: First of all, and unlike the years of the cold war, there is "significant uncertainty," especially with respect to threats and scenarios. It would be unrealistic to expect the same precision of definition that we formerly had. Given the "significant uncertainty," some system like the one Paul Davis briefed at QRAM can be useful in force planning. We must remember, however, that such treatments of uncertainty do not remove the uncertainty, but may decrease its adverse effects.

Data bases also need much attention. Although many existing data bases have untapped potential usefulness, there are serious current problems: gaps, inconsistencies, and releasability. O&S budget costs for military operations other than war were cited as needing more attention. Life cycle cost estimates have been prepared for individual systems, but the results are said not to be systematically incorporated in total budgets. Better understanding could lead to efficiencies and savings.

With respect to QDRs several items deserve special attention. The relation of periodic QDR outputs to POMs and the relatively "continuous" PPBS system in general is by no means clear. Some rationalization and better understanding could enhance both processes. Some concepts currently being analyzed and explored might profit from QDR highlighting. For example, some participants in the QRAM working

group on Readiness/Sustainability/Supportability found the concepts of "single, joint-capable forces," "rotation," etc. both promising and worthy of further exploration.

Some Eternal Analytic Truths. What any study effort accomplishes in a given time period depends not only on the combination of analysts, data, and models brought to bear in that period, but also on what had already been accomplished: the "initial condition" for that period. Therefore, a characterization of a study effort in terms of only its time duration--e.g., two days, two weeks, two months--and a binary classification of its initial condition--warm base or cold base--is necessarily incomplete. It is not surprising that casual usage of terms such as "quick response analysis" and "quick turn modeling" varies greatly from analyst to analyst, depending on experience and implicit memories and assumptions.

Basic Study Steps. Whatever the length of a study, it involves some basic steps: Problem definition is extremely important, and ideally includes understanding background of issues and decision makers, the scope and timing of decisions to be made next. This understanding constrains the study time and how it is allocated. One must decide how much quantification is essential, what measures of effectiveness are appropriate, how they are to be calculated, what data are needed, and just what structure the study should have. When possible, it can be very helpful to do an initial prototype study and brief its results to the decision makers: This tests the facets of the study plan and especially the extent to which the analysts understand the needs of the decision makers. Once the general study structure is designed and its major steps planned, there remains the execution: Required computer runs must be prepared, run, and analyzed. The analysis may suggest additional questions that should be addressed, if possible, to illuminate the decisions at hand. Finally, observations and conclusions must be carefully formulated and communicated to decision makers as inputs to their decision. The communication of results should seek to convey to decision makers some of the study rationale so as to give them the right level of confidence in the results--neither too much nor too little.

Systematic Studying of Major Force Structure Issues. Military decision making benefits greatly from systematic and repeated study of all major force structure issues. The model development, data collection, and analyst training should not be "quick response." However, once accomplished, they give a "quick response analysis" capability.

Scoping the Study. In framing the study question some important factors may be largely ignored, because analysts have implicit assumptions, are inhibited by political considerations, etc. For example, defense analysts rather than debating national security or defense requirements may "seek to do the best with what they have though they know it's not enough. This should not lead to non-reporting of analytic suggestions of force inadequacy.

Desirable Analytic Practices:

- Sensitivity analyses should also vary MOEs.
- As an analyst explains/defends an analysis, s/he should also listen to constructive criticism that may improve the analysis.
- An analyst must learn to deal with non-acceptance of his "truth" by a decision maker.

Some QRA Properties:

- Good analysts still may profit from training in QRA.
- Data collection may be the most significant time requirement, especially with a cold or lukewarm start. Model run time is often an insignificant part of the total time.

- A "quick" (aggregated) model is useful for initial insights and problem bounding, and as a step to other models--rarely as a stopping point.

Commentaries on Some Analytic Folklore.

What Makes for Sound QRA?

POPULAR FOLK TALE

QRA implies QR models.

Models need to be faster.

Models need to be "more accurate."

Object oriented programming gives speed and accuracy.

ERGO

Object oriented programming will solve QRA problems.

UNPOPULAR REALITY

Understanding interactions is prerequisite to good modeling, and takes thought.

Even object oriented programming takes much thought for good modeling

"More accurate" means fidelity, not detail.

More detail doesn't insure more fidelity.

More detail does insure slower models, tougher data problems, and complex interactions that are hard to analyze.

ERGO

QRA is a process, populated with educated, trained, and informed people, dedicated to scientific thought in organizations that foster aggressive pursuit of "truth."

Why So Much Model Criticism?

The combination of someone who doesn't really know how to do analysis running a model and briefing results to someone who doesn't know how to do analysis either, but thinks the briefer does, leads to bad conclusions.

Why the Interest in QRA When QDRs Come Up?

They haven't done anything since the last one to be prepared for the current one. Each time they go through one, everyone complains about the methods, wrings his hands, and feels bad. They get through it as best they can, and then promptly forget it, do other things, and then start all over again four years later.

Principles for MORS Special Meetings Participant comments available for this summary generally gave QRAM high marks. However, they also pointed out that QRAM planning and execution encountered challenging problems, some met in previous special meetings, but all in need of better approaches. Some comments bearing on challenges and approaches are summarized below:

Use of time in special meetings.

In QRAM issue groups and breakout groups, group dynamics played out in classic O.R. fashion: Their initial sessions usually dealt with "formulating the problem we face."

A frequent frustration at special meetings was also seen at QRAM: The difficulty of getting a group of analysts to focus on an issue in a way consistent with available discussion time.

Such observations of execution challenges at this and prior meetings led to the suggestion that MORS develop short training sessions for working group chairs, probably including practice exercises, and that such training be required "certification" for all working group chairs.

As often, there was the problem in planning QRAM to decide the best use of time to attain meeting objectives: In early planning there was much focus on "quick turn" *models*. This led to concern about possible neglect of basic "quick response *analysis*" in which models are *tools* requiring prepared *data* and careful use by trained and competent *analysts*. This led, in turn, to emphasis on major QDR *issues* and how *analytic* questions might be framed to address the issues. However, the experience of one analyst at QRAM led him to comment that he:

"Would have liked to have seen some workshops devoted to methodologies/tools available /applicable to QRA--for example

- QFD and AHP are useful methods to structure BOGSATs
- numerous COTS software tools (point-click simulation)

We spent too much time trying to be strategists (driven by QDR focus) vice being OR analysts."

General Observations on Meeting Planning and Execution.

In planning special meetings, MORS should seek to avoid common pitfalls like those of military requirements development: Excessive nitpicking of terms of reference during coordination and "nice-to-have" additions that don't quite fit..

Steps in planning and executing special meetings are analogous to steps in doing studies: 1) understanding the objectives and planning the approach, 2) executing the plan, and 3) reporting and communicating the results. QRAM did well in balancing time and effort for steps 1) and 2). Doing well in step 3) would complete its success.

Appendix E – Agenda



First Order Analysis: Exploring Quick Response Analysis Requirements and Methodologies (GRAM) AGENDA

October 1, 1996

0700	Registration	MORS Staff
0800	Introduction	Jackie Henningsen, GRAM General Chair
0810	Site Welcome	Charles Vollmer, V.P. Booz-Allen Hamilton
0820	MORS Welcome	Fred Hartman, MORS President
0830	Keynote Speaker -- <i>What is the QDR?</i>	William Lynn, Director, OSD/PA&E
0930	Break	
0945	<i>Analysis in the Spotlight</i>	Will O'Neil, Vice President, CNA
1030	<i>Intelligent Decision Support -- An Overview</i>	James Ignizio, University of Virginia
1120	<i>Framing the Issue -- The Methodology</i>	Bob Statz, GRAM Co-chair
1200	Lunch - Service Break (Pick-up Lunch from lounge or from cafeteria and take to your Session 1 meeting room)	
1230	Session 1 Issue Category Introduction C4ISR (Part 1) Recap/Modernization/Life Extension Readiness/Sustainability/Supportability Military Operations Other Than War	John Osterholz & Mark Herman David Graham Joe Angello & Bob Holz Gary Wheatley
1315	<i>Random Thoughts on the Analytical Challenge</i>	MG Mark Hamilton, Joint Staff, DD/J8 Doug Williams, GRAM Technical Chair
1400	<i>Methodology Case Study: What is the Value of BDA?</i>	
1445	Break	Issue Category Leaders
1500	Resume Issue Category Sessions	All Participants
1730	Mixer on Site	
1830	End of Day 1	

Issue Category Leaders

John Osterholz, Deputy Director, C4I Integration Support Activity, OSD
Mark Herman, Principal, Booz-Allen Hamilton
David Graham, Senior Analyst, Institute for Defense Analyses
Joe Angello, Director Readiness Programs & Assessment, OSD/P&R
Bob Holz, Senior Scientist, Army Research Institute
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Wednesday, October 2, 1996

0730	Synthesis Group Meeting	Stu Starr, Paul Davis, Clay Thomas
0800	Session 1 Working Groups	Session 1 Issue Category Leaders
1100	General Session in Auditorium: Hot Wash Session 1	Session 1 Issue Category Leaders
1200	Lunch - Service Break (Pick-up your lunch from lounge or from cafeteria and take to your Session 2 meeting room)	
1230	Session 2 Issue Category Introduction C4ISR (Part 2) WMD Stability and Deterrence Force Structure: Risk & Uncertainty Infrastructure/Business Efficiencies/Right Sizing	John Osterholtz & Mark Herman Bruce Bennett Bob Statz & Paul Davis Dan Barker
1315	<i>Adaptiveness in National Defense</i>	Paul Davis, RAND
1400	<i>The Art of MOE Development</i>	Roy Rice, QRAM Co-chair
1445	Break	
1500	Resume Issue Category Sessions	Issue Category Leaders
1730	End of Day 2	

Thursday, October 3, 1996

0730	Synthesis Group Meeting	Stu Starr, Paul Davis, Clay Thomas
0800	Session 2 Working Groups	Issue Category Leaders
1100	General Session: Hot Wash Session 2	Issue Category Leaders
1200	Synthesis Group Hot Wash	Synthesis Group Leaders
1220	Closing Comments	Jackie Henningsen
1230	End of Mini-symposium	

Report Writing Workshop

1330	General Meeting	Roy Rice
1400	Time as needed for report writing	Organizing Committee, Synthesis Group,
1700	End of Report Writing Workshop	Issue Category Leaders & Reps, Volunteers

Issue Category Leaders

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Mark Herman, Principal, Booz-Allen Hamilton
Bruce Bennett, Senior Analyst, RAND
Bob Statz, Principal, Booz-Allen, Hamilton
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Appendix F - List of Participants



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Mini-Symposium: *First Order Analysis: Exploring Quick*
Response Analysis Requirements and Methodologies
(GRAM)

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